MACHINE DESIGN

May 1952

Ceramic Coatings for High-Temperature Se[rvice]

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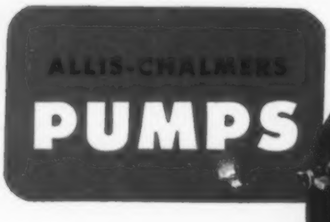

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MACHINE DESIGN

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

Vol. 24—No. 5 **May 1952**

DESIGN FOR PRODUCTION • STYLING • MATERIALS SPECIFICATION • DESIGN ANALYSIS • MACHINE COMPONENTS • ENGINEERING MANAGEMENT

Over the Board

Calling All Authors!

In order to highlight the editorial aims and objectives of MACHINE DESIGN, it has long been on the agenda of the editors to produce an editorial guidebook. Feeling that such a booklet, directed primarily to authors, would be of considerable value, associate editor Roger Bolz has prepared a 16-page answer to "That Article—Why You Should Write It and How." Although the booklet is directed to engineer-writers, it also serves as a concise review of MACHINE DESIGN's field. In the main, however, our hope is that it will inspire and orient the thinking of many engineers as well as assist them in achieving the coveted prestige of authorship.

In the event you would like to have a copy for guidance, don't wait until we look you up. Drop us a line and we'll be glad to send one along.

This Month's Cover

Ever since the advent of the jet engine, engineers have been seeking materials capable of resisting the intense heat without failure in service. One possible answer to this problem—ceramic coatings—is reported in the article beginning on Page 122. Depicting this dramatic and challenging design problem, Penton artist George Farnsworth's rendering of a modern jet fighter, the Navy's F9F "Panther," flashing across the cover fairly breathes the inferno confined within the screaming engines.

Nomograph Phobia

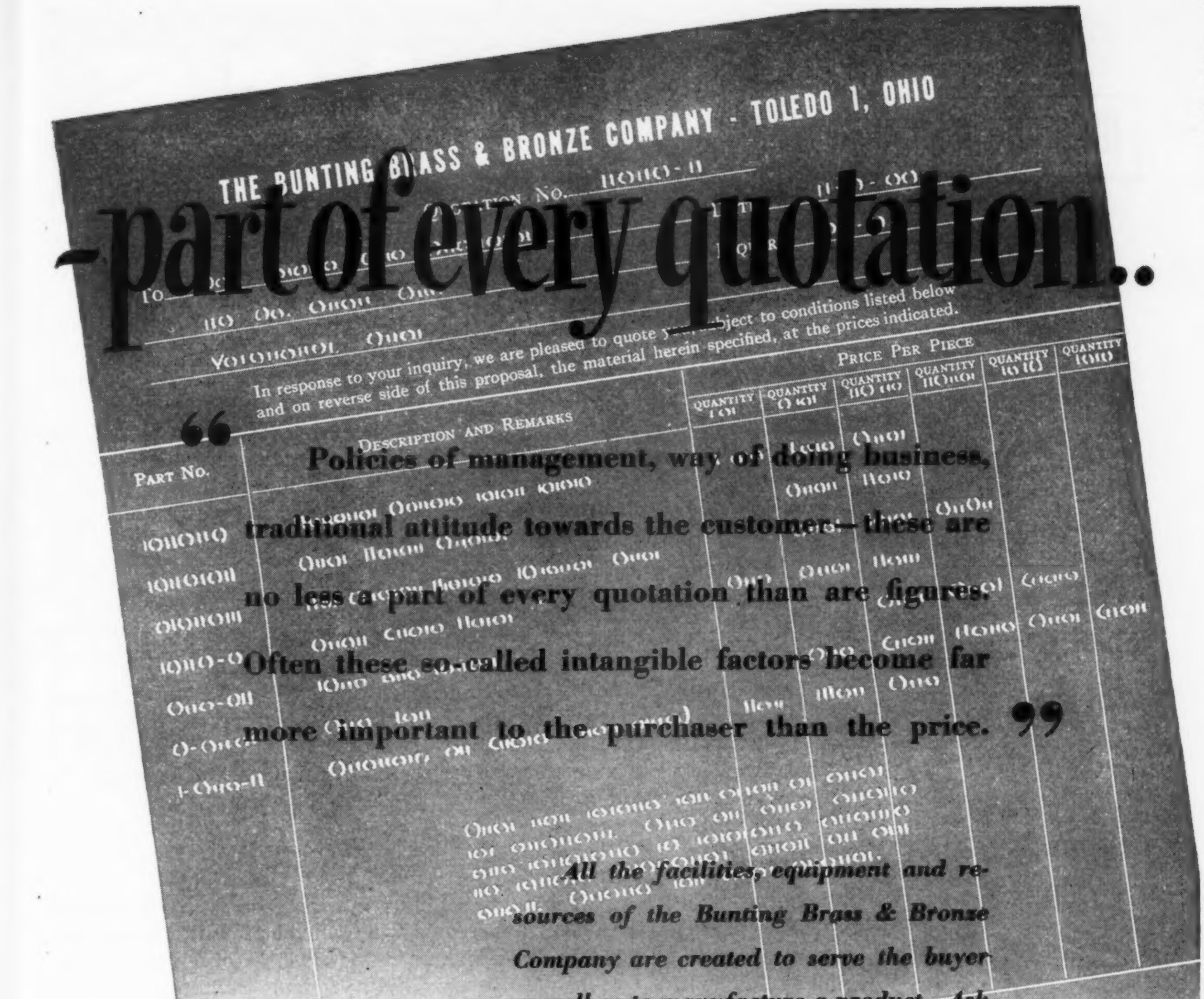
If you are one of those engineers who shies away from nomographs, take a look at the simple and effective method of constructing such charts without tedious calculations or trial and error, discussed in John Baude's article beginning on Page 155. His method should dispel any aversions with respect to constructing these useful tools. Tests to determine whether or not a family of data can be made into a nomograph are included, together with basic forms to indicate the type of nomograph and polarity of scales.

Two Shakes

We have often wondered how many seconds it takes to "say Jack Robinson" and how long is "two shakes." Just in case any of you carry a certain mental picture of a "shake," we have it on good authority that it is something much more fleeting than what you do to a cocktail. By definition, one shake is one one-hundredth of a millionth of a second. Does anything happen that fast, besides the honking of the fellow behind you when the traffic light changes? Yes, atomic explosions, for one thing. The problem of controlling instruments that give information about what happens before they are destroyed by atomic explosion has prompted the development of an electronic clock that measures intervals of one-fiftieth of a shake, or one-fifth of a billionth of a second! (Reading time: 3 billion shakes).

Electric Motor Drives

Reprints of the "Electric Motor Drives" article from the April issue are being made available as separately bound booklets. A heavy paper cover and a subject index increase their usefulness as reference and for filing. The 64-page article presents the basic factors involved in selecting and applying motors with respect to mechanical, electrical and application considerations. Readers using the April business reply postcards to request single copies are receiving them free of charge. A nominal price of $1 for additional single copies, with discounts for quantity lots, is being charged to help defray expenses. From present indications the original overrun of 11,000 copies may not be sufficent to fill requests which are streaming into the office.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MACHINE DESIGN TOPICS

...IN ENGINEERING AND RESEARCH

Gas Turbine Runs on Sawdust

Combustion efficiencies of 92.5 to 99 per cent are reported for a sawdust-fed gas turbine which can be used as a power unit in sawmills. Having heat-release rates up to 15 times greater than boiler installations using wood fuel, the experimental furnace feeds the resulting gases to a converted B-22 aircraft turbosupercharger which rotates at 24,000 rpm. The fuel used in tests at the Oregon Forest Products Laboratory was Douglas fir sawdust, although other waste woods can be used.

Ionic Cloud Acts as Loudspeaker

A new loudspeaker utilizes an ionic cloud produced by a heated platinum electrode in place of the conventional mechanical diaphragm. Now being tested by the Institute of Inventive Research, the loudspeaker produces sound waves by expansion and contraction of the cloud, which responds to changes in strength of a high-frequency electrical field.

Air-Flow Studied at Mach 10

Studies of air flow at Mach number 10 (ten times the speed of sound) are being made in the Naval hypersonic wind tunnel at White Oaks, Md. Air is supplied at 3000 psi and is heated to 900 F in order to prevent liquefaction in the five-inch venturi working section. Both pressure and optical measurements of air flow are made for later use in missile and projectile design.

Quartz Paper Withstands 3000 F Temperatures

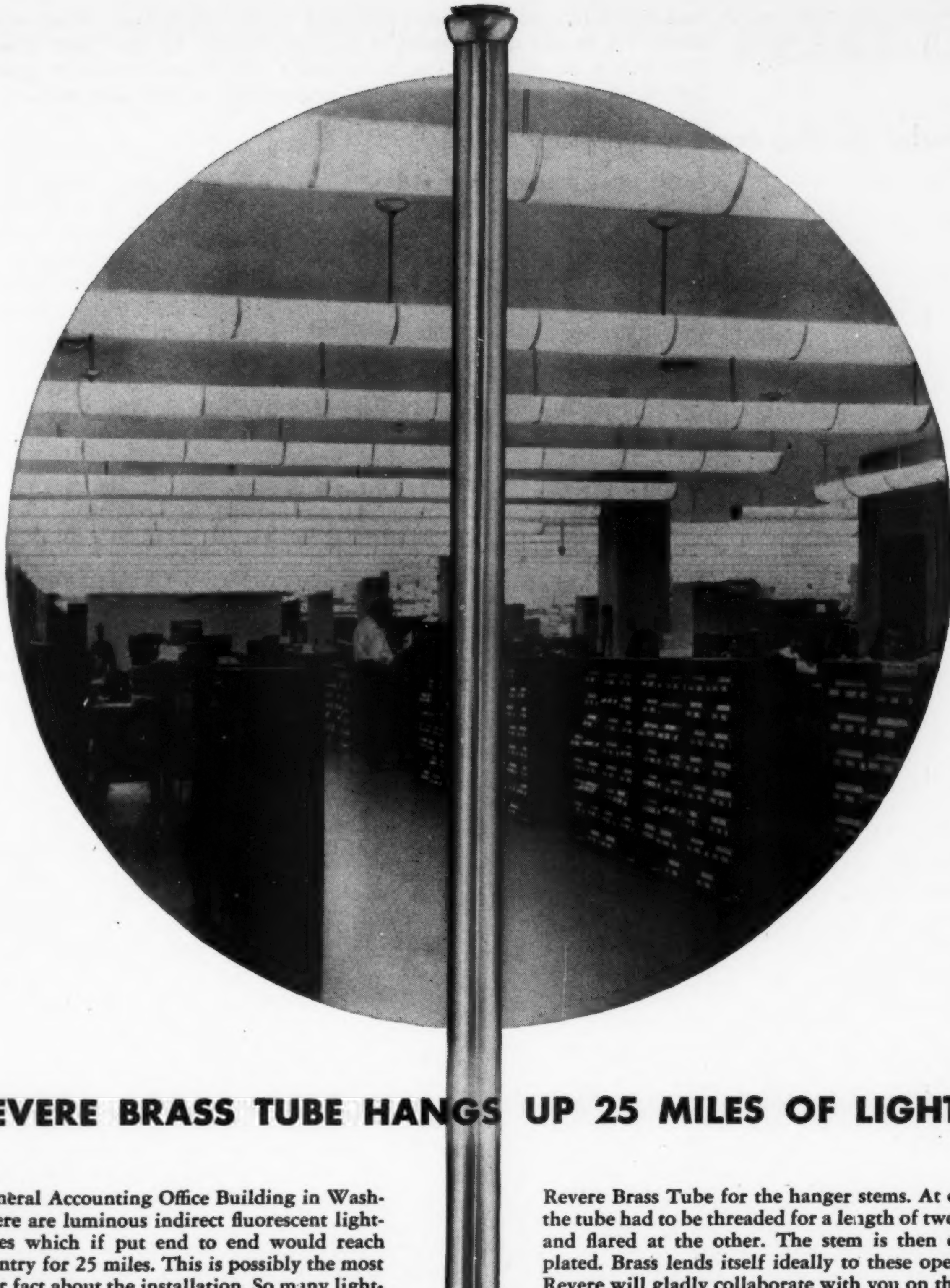
Porous quartz-fiber paper, manufactured on conventional paper-making machines, can withstand temperatures up to 3000 F—compared to about 1000 F for asbestos. Lower in cost than asbestos insulation material, the quartz paper has the additional advantage of containing no boron, suggesting possible uses as insulation in nuclear energy power plants and in components subject to atomic radiation. The new paper, as produced in a test run at the Naval Research Laboratory, is 0.005-inch thick, and has excellent dielectric and ion-exchange properties.

Magnesium Repaired with Gas-Shielded Welding

Magnesium, which ordinarily ignites at about 600 F, is now being successfully welded at temperatures as high as 7000 F by enclosure of the weld area with helium gas. Before the method was adopted, cracked engine casings at the Hill Air Force Base were sold for scrap. With the Heliarc process, which excludes oxygen during welding, these expensive B-26 parts are salvaged.

Odor Removed from Synthetic Foam Rubber

The objectionable chemical odor of synthetic foam rubber has been eliminated in a new "cold" polybutadiene which is suitable for cushioning material. The odor was traced by Goodyear to the styrene component,



REVERE BRASS TUBE HANGS UP 25 MILES OF LIGHT

In the General Accounting Office Building in Washington there are luminous indirect fluorescent lighting fixtures which if put end to end would reach across country for 25 miles. This is possibly the most spectacular fact about the installation. So many lighting units are needed in this seven-story structure because it occupies an entire city block and has no court to admit daylight to interior areas. There are 10,000 employees, and large numbers spend all their working hours under electric illumination. The reflectors are made of extruded Plexiglas acrylic plastic, and deliver 90% of the light to the ceiling, from which it is reflected downward, preventing glaring dazzle spots. There are nearly 33,000 lighting units in the building. A Revere man who visited the office reports that the lighting is perfect.

The units or luminaires were made by the F. W. Wakefield Brass Company, Vermilion, Ohio, using Revere Brass Tube for the hanger stems. At one end the tube had to be threaded for a length of two inches and flared at the other. The stem is then chrome-plated. Brass lends itself ideally to these operations. Revere will gladly collaborate with you on the specification and fabrication of Revere Brass.

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used heretofore with butadiene in cold rubber production. First experiments led to the development of a polybutadiene by the "hot" process. This solved the odor problem but strength and toughness proved unsatisfactory—leading to the successful development of the cold latex.

Dental Molding Process for Small Molds

Small casting molds or matrices for positioning intricate parts can be made by a simple new dental molding process. A wafer of sheet plastic, 0.064-inch thick, is first placed on top of a plaster of Paris model, then heated until it becomes soft and moldable. The model and wafer, in the tray of the Torp and Ornstein molding machine, are then placed under an air pressure element where a rubber diaphragm is expanded under 25 to 50 psi pressure to form the plastic into a replica of the model.

...IN GOVERNMENT AND INDUSTRY

Procurement Manual Lists Government-Purchased Items

Billed as "the only source of information in the federal government covering the procurement activities of all major military and civilian agencies," a revised edition of the Government Procurement Manual has just been issued. Over 5000 items and classes of items for which federal agencies are in the market are listed along with a military and civilian agency index, and a listing of the location of the appropriate procurement offices. Copies will be available for inspection at local chambers of commerce, Department of Commerce field offices and the principal government purchasing offices.

Time Lag in Developing Defense Equipment

New weapons and military equipment require two to eight years of design and development time before the first production unit is available—showing the vital importance of time in building a defense structure. According to the Department of Defense, 7 years are required to develop a jet fighter, 6 for a bomber, over 5 for a transport plane or destroyer. Over 4 years are needed for a new medium tank or recoilless rifle, and about 3 for a minesweeper or landing-ship tank. Design and testing require the longest single time period, with preparation of requirements, contract negotiation, development of working plans, and manufacturing setup each requiring lesser periods.

Facilities Inventory Plan Proposed

Since government procurement officers usually have inadequate information on facilities of smaller firms, the Small Defense Plants Administration has proposed a nationwide inventory of production capacity. State governments would be asked to modify their present facilities files to conform with the plan, and standardized questionnaires, procedures, and industry and equipment code indexes would be used. Basic information which would be gathered on each plant would be: a facilities and equipment inventory; a "know-how" or personnel report; a financial ability statement; and information on prices and delivery periods.

Industrial Participation in Atomic Reactor Program

Additional proposals from industry for preliminary studies of the practicability of privately financed atomic reactors will be considered this spring by the Atomic Energy Commission. Following the pattern of present agreements between AEC and four groups of private companies, the new agreements with other interested companies will call for studies of engineering, design, construction and operation feasibility; of economic and technical aspects; and of the research and development work needed.

Quantity or Quality?

COMPETENT authorities continue to warn against the growing shortage of engineers. Although the present situation appears serious enough, we are told that worse is to come. Predictions are based on figures showing that only 28,000 engineering students in all categories will graduate in 1952 to meet an estimated current demand of 60,000 to 90,000 engineers.

Although the number of graduating engineers represents a drop of 10,000 compared with 1951, and 20,000 compared with the peak year of 1950, it is actually two and one-half times the number graduating in 1940. It is fair to ask, therefore, whether the volume and complexity of engineering work is correspondingly greater now than it was twelve years ago.

Of course, when it is considered that the initial development of a modern fighter, the F-86 jet plane, required 1,137,000 engineering manhours compared with 41,800 for the propeller-driven P-51 of World War II, there is real cause for anxiety insofar as present defense needs are concerned. But even with the acknowledged tremendous complexity of the newer plane the question might well be raised whether some of the 27-fold increase in engineering manhours could not perhaps be charged to lower efficiency as the result of undue emphasis on quantity of engineers at the expense of quality.

There is some evidence that in the present emergency some manufacturers are not counting on permanently expanded engineering staffs. The recent overwhelming volume of want-ads for design engineers indicates a need to get urgent jobs done quickly by experienced men. On the other hand, although engineering college seniors are still receiving job offers in bewildering numbers and at what seem to old-timers to be fantastic salaries, the proportion of offers that involve design is insignificant compared with other categories. This might well indicate reluctance to embark on a long-term program of developing design-engineering manpower.

The necessary design manpower to keep our country free and strong can never be maintained by a "feast or famine" policy of hiring great numbers of designers when a big job must be done and releasing them at the end of the project. There must be developed a permanent, hard core of able design engineers, hand-picked and trained to a high pitch of competence and experience. One source of raw material for this core (or corps) is at hand in engineering colleges.

Now, when the demand for engineering manpower is at a high level, is the time for engineering executives to convince top management of the urgent need for a more far-sighted policy, one that will include a permanent program of recruiting the best brains in each graduating class. Design—the most exacting and the most challenging of the branches of engineering—should be taking the cream of the crop. Permanent quality rather than temporary quantity should be the goal.

Colin Carmichael

EDITOR

Electric Controls

. . . how to design for maximum performance with standard compone

SYSTEMATIC APPROACH to the design of controls—evaluating costs of alternative systems with respect to performance and maintenance—will develop the best control for a particular application. In this article, costs of standard protective enclosures and various types of motor starters are compared. Typical examples of simplified controls indicate the possibilities of reducing the number of components to provide a more economical but equally effective control system.

TODAY, the trend in design is toward more automatic machines and increased production speeds, *Fig.* 1. These, as a rule, require more elaborate electric controls and control systems. Confronting the designer, therefore, is the problem of what controls will do the job not only most effectively but also most economically.

In the competitive field, the cost of a control may often mean the difference between profit and loss. On machines where first cost is not a deciding factor, the choice of controls may affect operating and maintenance costs. The question of repeat sales and reputation of the machine builder is at stake.

By carefully considering all the economic factors or variables in electric controls the machine designer can effectively determine the best systems for a particular application. This discussion will formulate an economic approach to the problem of choosing the proper control components consistent with the requirements of the job. No attempt will be made to rate one make of control vs. another but rather the analysis will determine how much or how little control is actually needed. Cost comparisons, however, will help decide whether it is worthwhile to add that "other" control component or whether the point of diminishing returns has been reached.

There are many cases where the application obviously determines the type of control and there isn't any doubt concerning the ideal control. Nevertheless, by formulating an organized economic analysis of each control problem, less is left to guesswork.

In selecting electric controls, the machine designer should consider the following basic economic factors which influence the proper choice.

1. First cost
2. Installation cost (mounting and wiring)
3. Operating cost
4. Maintenance
5. Depreciation
6. Obsolescence.

The first cost usually appears to be the most tangible portion of the entire economic evaluation of the control on a particular machine. The designer, however, must not be misled into thinking that the least amount of control or the cheapest control is the most economical. Adding sufficient control to insure safety for the operator, to protect the motor and driven machine, to provide the necessary sequence in machine operation, and to reduce maintenance compensate readily for the extra expense that may be involved.

Many times the machine designer is faced with

Table 1—Cost Comparisons of Magnetic Linestar for Squirrel-Cage Motors

Cost Index of Control (%)	Type of Starter	Diagram of Power Circuit
120	Combination linestarter with 600-volt circuit breaker	
100	Combination linestarter with 250-volt circuit breaker	
93	Combination linestarter with fusible switch	
[illegible]	Combination linestarter with nonfusible switch	
65	Nonreversing linestarter	

By J. C. Ponstingl

Consulting and Application Engineer
Westinghouse Electric Corp.
Cleveland, Ohio

the problem of how far to go in the application of electric controls. How much of the machine should be under automatic control and how much should be manual or under the command of the operator? It is conceivable that a designer could go to the extreme and end up with expensive or purposeless controls.

Before a designer can intelligently decide what type of control to use, and how much, he must first consider the following points.

1. What is the function of the machine?
2. What type of operator will run the machine?
3. Is the machine general-purpose or specialized?
4. Is the machine competitive?
5. What type of maintenance will be available?

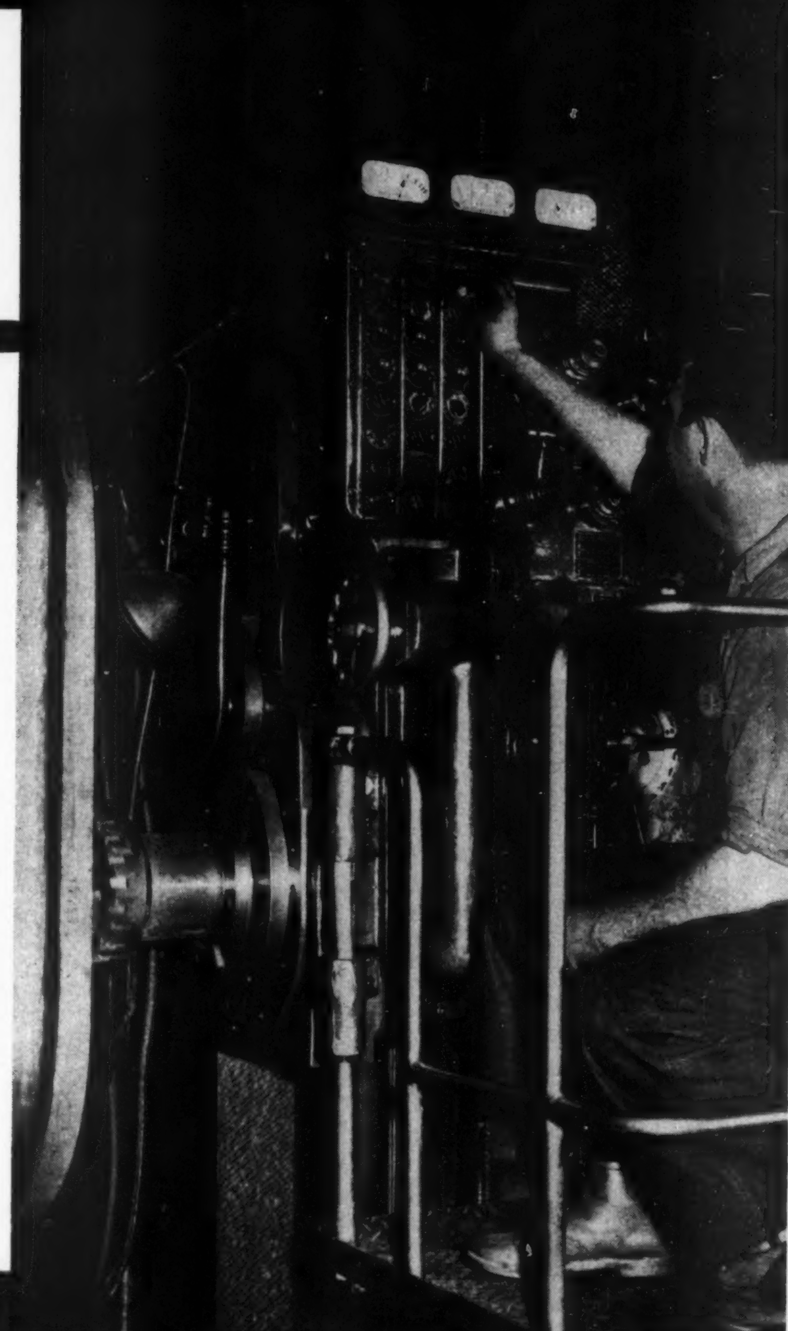
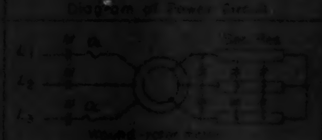
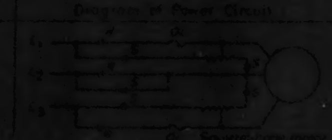
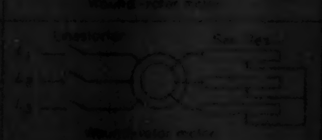
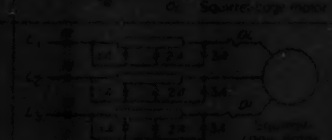
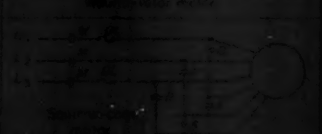
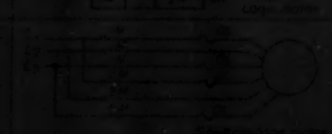
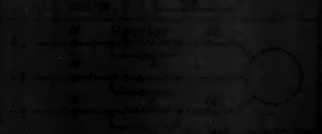
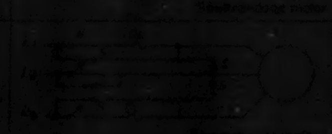


Fig. 1—By eliminating the need for calculations by the machinist and by providing him with fingertip control of the machine, these convenient controls and indicating instruments are credited with effecting a substantial saving in machine time

Table 2—Comparative Costs of Cushion Starters for Polyphase Motors

Cost index of Motor and Control (%)	Type of Starter	Diagram of Power Circuit	Cost index of Motor and Control (%)	Type of Starter	Diagram of Power Circuit
[illegible]	Magnetic Starter		[illegible]	Magnetic Auto-transformer	
[illegible]	Manual Drum Controller		[illegible]	Magnetic Primary Resistance	
[illegible]	Star Delta		[illegible]	Part Winding	
[illegible]	Magnetic Primary Reactance		[illegible]	Manual Auto-transformer	

6. Is the machine for domestic or foreign use?

What is the function of the machine? On a simple bench grinder, the function is obvious. An electric motor rotates the grinding wheel, requiring some type of control to start and stop the motor. On a simple bench lathe, the function may be to hold and rotate work in either direction while tools are brought in contact with the work to produce various cutting actions. Obviously the controls must be capable of starting, stopping and reversing the direction of rotation of the drive motor. In some cases, the reversing operation may be performed mechanically. Then, starting and stopping are the only electric control requirements. As machine functions become more involved, addition control equipment is needed. In general, the functions—or requirements of the application—dictate the basic control. Even though the electric controls of some machines may appear complex they can be reduced to a combination of relatively simple circuits.

One basic circuit is shown in *Fig.* 2. It illustrates a standard nonreversing linestarter circuit for a three-phase squirrel-cage motor. The device *M* represents a three-pole line contactor, and the device *OL* represents heaters in the thermal overload relay. Low-voltage protection is a term applied to this control scheme because it prevents unexpected and unsupervised restarting of the motor which otherwise might injure the operator or damage the motor and driven load after the motor has been stopped because of low voltage or power failure. Such a scheme makes it necessary for the operator to press the start button to restart the motor regardless of whether the motor has been stopped by voltage failure, operation of the stop button, or operation of the overload relay.

The pushbuttons are both of the momentary-contact spring-return type, one normally-open and one normally-closed. When the start button is depressed, the coil of contactor *M* is energized closing the *M* contacts to energize the motor. The auxiliary or interlock contact M_a closes, completing a circuit around the start button so that when this button is released, the coil *M* will remain energized.

When the "stop" button is depressed, the coil is deenergized and the opening of the auxiliary contact places the circuit back in the normal off position. In the event of power failure, the dropping out of the contactor *M* also opens the auxiliary contact M_a and it will be necessary to depress the start pushbutton to resume operation upon return of power. If a particular machine has two 3-phase motors that must be started and stopped independently, then possibly

[redacted]

Fig. 4—Diagrams showing how an interlock contact for an indicating light circuit may be eliminated

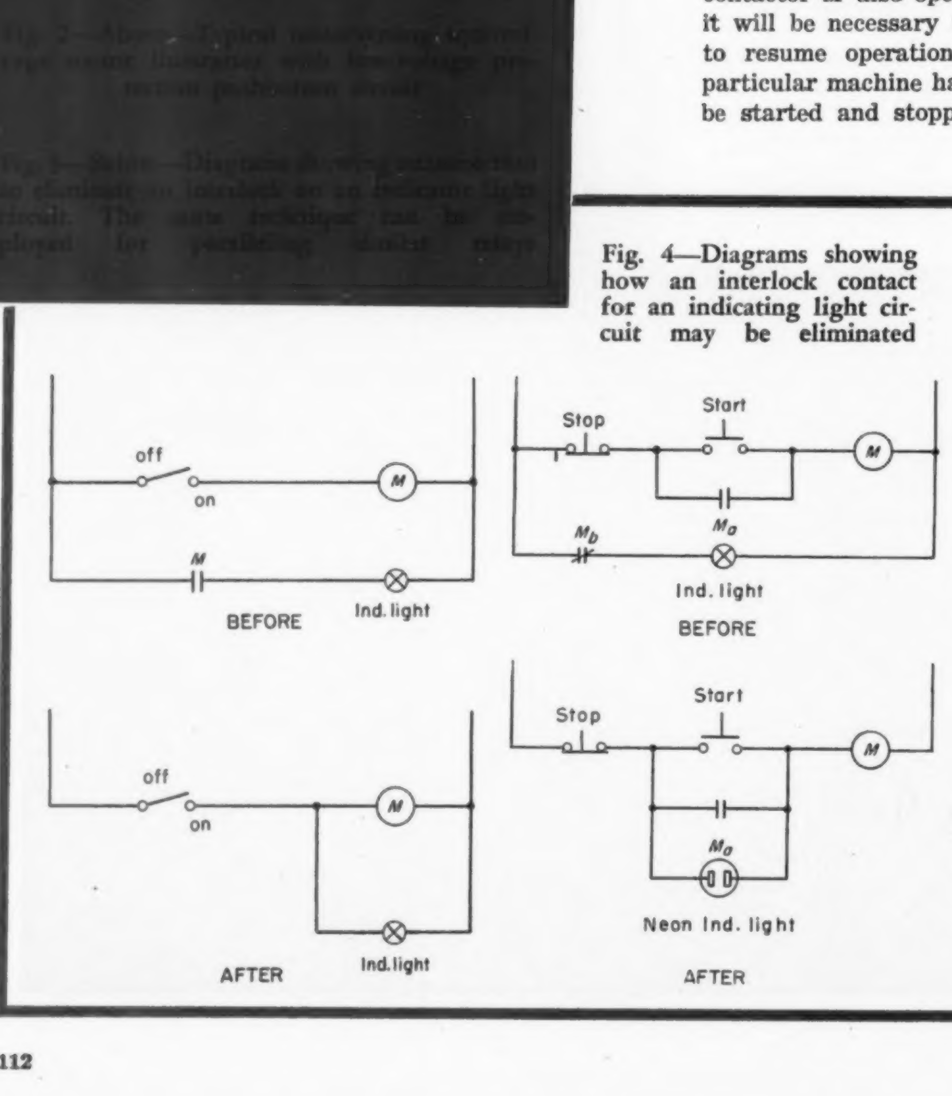
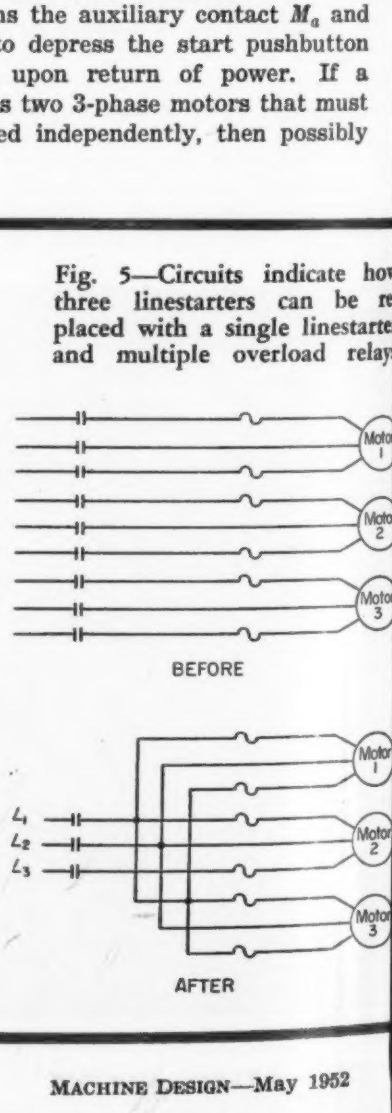


Fig. 5—Circuits indicate how three linestarters can be replaced with a single linestarter and multiple overload relays



two such linestarters may be required.

What type of operator will run the machine? On simple applications involving on-off switches, the question may be hinged only on the physical fatigue connected with the operation of the switch. If the switch is operated frequently and by women operators, an easy-operating, handle-type may be the answer. Such a switch will be more expensive than the simplest of the on-off types. Also, a pushbutton and linestarter may be used. Referring to *Fig.* 1 the overload relays insure against the operator overloading the motor beyond the capacity or horsepower rating of the machine.

Programming controls may be built into the machine where unskilled operators are employed. When several operators with different operating techniques may be using the machine, the human element may be sufficient to produce an undesirable variance in product tolerance. As an example, on a simple resistance spot welding machine, one operator might energize the spot welder too long and produce burned spots while the next operator may use too short a weld time and produce weak welds.

If a particular machine such as a bench lathe is operated by a highly skilled operator, starting, stopping, reversing, positioning, etc., can be handled at the discretion of the operator. Perhaps there would be no necessity for overload protection on the drive motor, since the operator could be aware of the capabilities and limitations of the machine.

Tools in laboratories or home workshops invariably have simple controls without overload protective equipment simply because it is assumed that the operator will be considerate of the equipment. In general, the more people using a machine, the more automatic the controls must be.

Usually on production machines, it is more desirable to use automatic controls rather than rely on the discretion of the operator especially where it will affect the tolerances of the product. For example, limit switches may be utilized for determining travel and cutting distances or timers may be employed for controlling heating and other cyclic operations. It should be kept in mind that mechanical limit controls and timers may at times be more economical than their electric counterparts.

On a planer drive, for example, electric limit switches are used most effectively since the table motion is controlled by an electric motor and consequently the forward-reverse-stop intelligence to the motor is best transmitted through limit switch contacts.

Where the power requirements are small as on a small grinder, mechanical-dog tripping limits are used to actuate the reversing motion of the grinder table. The type of drive usually dictates whether the limits should be mechanical or electrical. It is always desirable to make the system as simple as possible, consistent with dependable operation.

Is the machine general-purpose or specialized? On a special resistance-welding machine, the timer range may be limited to the particular job being performed. In this case, the type of timer control will certainly be less expensive than that for a versatile welder needing a multitude of timer ranges as well as control functions for weld time, forge time, temper time, etc.

A special cut-off machine might require only a

Fig. 6—For dc circuits, reconnecting a pilot contact eliminates need for a relay

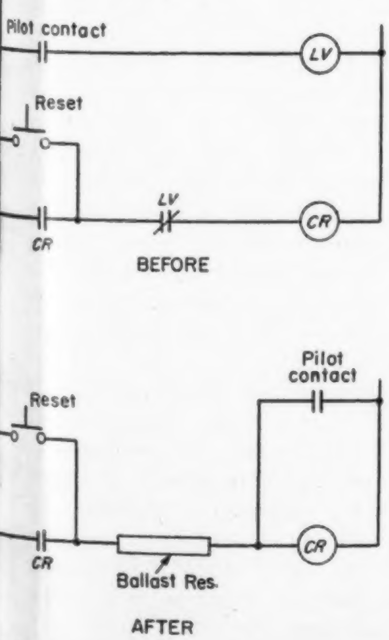


Fig. 7—For ac circuits, a high-reactance transformer or a rectifier may be employed to eliminate the need for a relay, shown in *(a)* and *(b)*, respectively

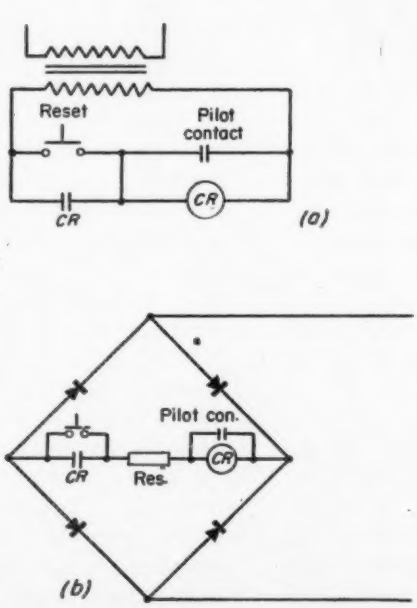


Fig. 8—Diagrams showing how a relay can be eliminated by using a double-wound coil on one relay

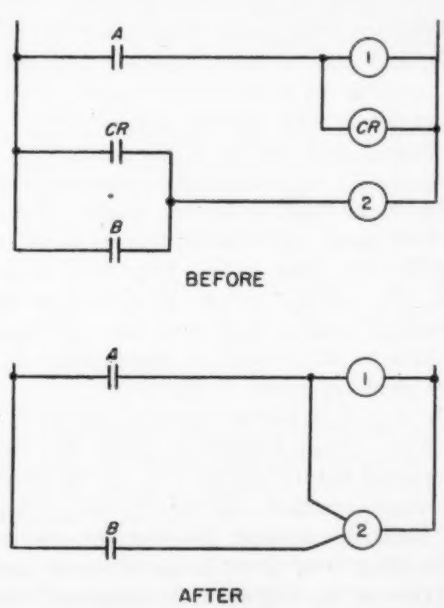


Table 3—Comparative Costs of Enclosures

NEMA Enclosure	Description	Features	Relative Cost (%)
Open-Panel	No enclosure	No protection	100
Type I	General-purpose	Conventional indoor applications	117
Type IA	Semidust-tight	Cover gasket added to Type I enclosure	129
Types III & IV	Watertight	Protection against extreme moisture conditions both indoor and outdoor	203
Type V	Dust-tight	Completely gasketed to exclude dust	161
Type VII	Class I Group D*	Explosionproof against vapors	316
Type IX	Class II Group G*	Explosionproof against dust	240
Type XII	Machine JIC†	Mounting feet, gasketed door and elimination of knockouts to exclude coolants and lubricants	183

* National Electric Code designations for hazardous locations.
† Joint Industry Conference designation for automotive production machines.

nonreversing linestarter for the drive motor. On the other hand, a versatile bench lathe would certainly need a reversing linestarter to permit spindle rotation in either direction.

Is the Machine Competitive? The cost of controls may adversely affect the selling price of the complete machine. Nevertheless, a machine designer cannot afford to skimp on control quality below the requirements of the application. On the other hand, an expensive electronic control system would not be used if competition satisfactorily uses standard and inexpensive control equipment. Additional control components or more refined control would only be used to present "plus" features in the product.

If the control requirements are fairly simple, say requiring a linestarter or switch, there is little opportunity to cut corners in the cost. Where a multiple number of components are being used, however, certain dexterity in circuit design will assist in reducing the number of contactors, relays, and interlocks. For example, in the simple application of an indicating light as shown in *Fig.* 3, the cost of an interlock contact can be eliminated by connecting the indicating light in parallel with the magnet coil. Certain discretion must be used in this type of application. It can be seen that in the case of a large dc contactor coil, the voltage surge at the time the coil is deenergized might burn out the indicating lamp. No trouble in this respect is experienced on small contactors such as sizes 1 and 2.

In *Fig.* 4 is another system which can be employed to have visual indication when the contactor is deenergized without employing an extra normally-closed interlock contact. In using this scheme, it should be remembered that the current consumption of the indicating lamp must be much lower than the drop-out current of the contactor or relay coil being used in the circuit, otherwise the contactor or relay may either not drop out or overheat in the open position. A low-wattage lamp such as a neon lamp works satisfactorily.

If a group of motors as shown in *Fig.* 5 is to be controlled together then a savings from 10 to 25 per cent can be realized if they are grouped to use a linestarter with multiple overload relays. In comparing a linestarter with overload relays, vs. a line contactor and thermal protection built on the motor, there is practically no first-cost differential. On polyphase-integral horsepower motors, however, some savings may be realized in that no control wires from the motor to the line contactor are required on the linestarter with overload relays. In addition, there may be some disadvantage to the long reset time when the motor has built-in thermal protection. From all indications the linestarter with overload relays is more economical.

When a control includes a large number of relays, it is often profitable to scrutinize the circuit in an attempt to make one relay do the job of two or to eliminate unnecessary operations.

In many circuits a normally-open contact on a pilot device (e.g., thermostat) must be used to de-energize a holding circuit. The interrupting capacity of the pilot contacts may be insufficient to interrupt the current of the circuit to be de-energized. Usually the closing-current capacity of a contact is greater than the interrupting capacity of a contact. An additional relay must then be introduced to provide a normally-closed contact, capable of de-energizing the holding circuit. Referring to *Fig.* 6 Relay *LV* is energized by the pilot contact to de-energize the *CR* relay in the holding circuit. By simply connecting the pilot contact to short out the *CR* relay coil, the *LV* relay is eliminated. A ballast resistor must be added to limit the short-circuit current. Since part of the voltage drop is normally through the ballast resistor, a lower voltage *CR* coil must be used. This scheme works well for dc circuits.

On ac circuits, the ballast resistor may prevent the relay from picking up (the pickup current of an ac relay is usually higher than the hold-in current) therefore, it may be necessary to use a scheme as shown in *Fig.* 7. In *Fig.* 7*a* a high-reactance transformer is used to limit the short-circuit current. *Fig.* 7*b* shows an alternative using a rectified ac circuit.

In an attempt to "stretch" the number of contacts, the technique of using a relay with a double-winding coil may be used. Referring to *Fig.* 8, if pilot contacts *A* and *B* are available where contact *A* must energize relay 1 and relay 2 and contact *B* must energize only relay 2, relay *CR* may be eliminated by using a two-winding coil on relay 2.

What type of maintenance will be available? On machines for small job shops, farms, etc., a simple sturdy control, (e.g., safety switch) is preferred to complicated magnetic controls. The owner or operator must be able to understand and service his controls. Also, in certain sections of steel mills the operators must be able to make adjustments while wearing gloves. Fine delicate controls may suffer under the rough treatment.

In large plants supporting highly skilled maintenance

crews, more complicated controls are acceptable. Naturally, machine tools used on high-production jobs and operated by a large crew of semi-skilled operators, must be under a systematic control setup. Having one skilled worker maintain a group of automatic machines operated by less skilled operators is less expensive than having a group of skilled operators on less automatic machines.

In many spread-out plants it is desirable to group the controls for all machines in a centralized location to facilitate maintenance, *Fig* 9. Factory-assembled controls are 110 to 125 per cent the cost of equivalent individual controls depending on the complexity of interlocking and sequencing between controls. Many cases have shown this small increase in cost is justified.

Is the machine for domestic or foreign use? Vital factors associated with this problem involve

1. Power supply—dc voltage or ac frequency and voltage
2. Safety standards
3. Electrical codes—JIC, AIEE, NEMA, etc.

If a standard machine is expected to be used in various localities where different ac power supplies exist, the addition of dual-voltage coils or control transformers with multivoltage primary taps permits versatility of installation without resorting to coil changing for different localities. In this way a machine designer can make one style of control versatile enough so that his machine can be shipped to various places and fit the requirements of those localities. Such standardization of control means a saving to the machine builder.

A guide to the minimum standards for electric control is provided by such rules as the National Electric Code, NEMA and AIEE. These rules were prepared in order to protect wiring and apparatus against short-circuits, to protect operators, to reduce fire hazards to a minimum, to insure uniformity of practice, and to provide a minimum standard for electrical installation requirements.

There may be instances when close observance of the codes and other rules is not mandatory but, in most cases, they must be followed. It should be understood that although the codes provide an excellent basis for determining minimum requirements, they do not always establish the most desirable practice. An installation should always fulfill the minimum requirements of the codes. Some conditions, however, may demand controls superior to code requirements.

Once a decision has been reached as to how much control is to be used on the machine, a familiarity with control devices and systems will simplify an in-

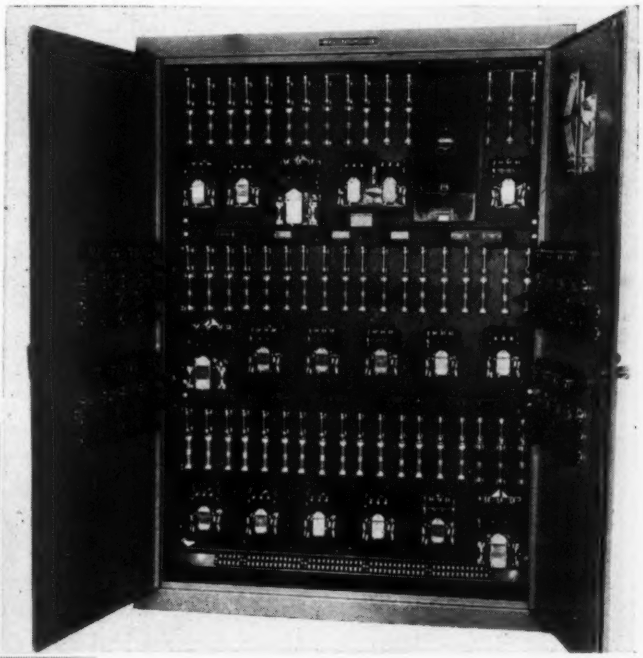


Fig. 9—Above—Compact mounting of all controls for an automatic machine. Controls of this type, mounted and wired in the cabinet may be more economical than mounting the controls on the machine

Photo, Courtesy National Acme Co.

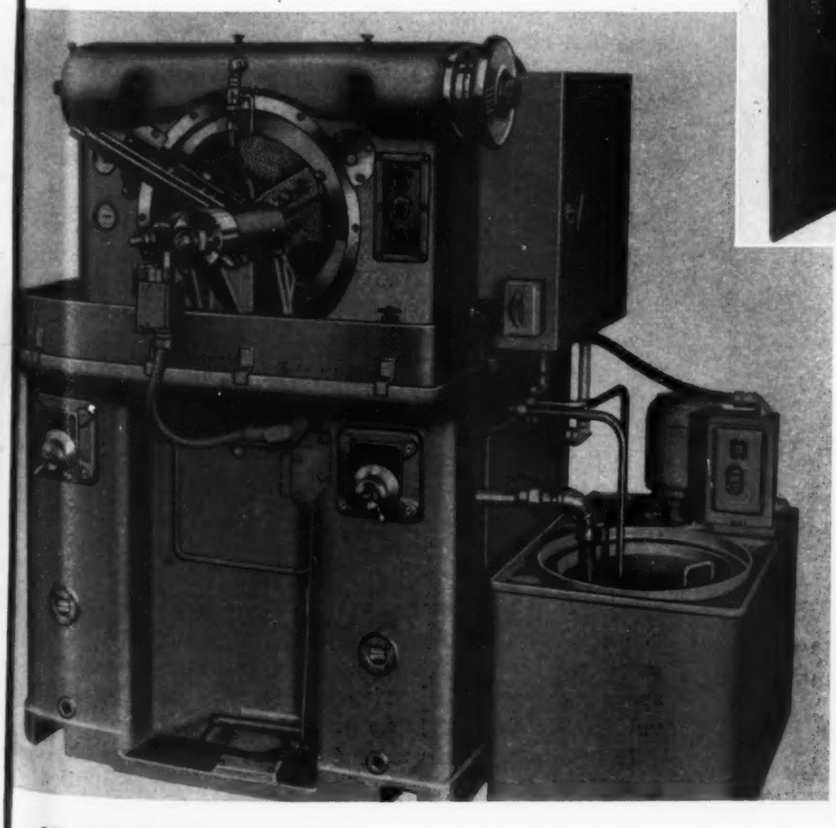
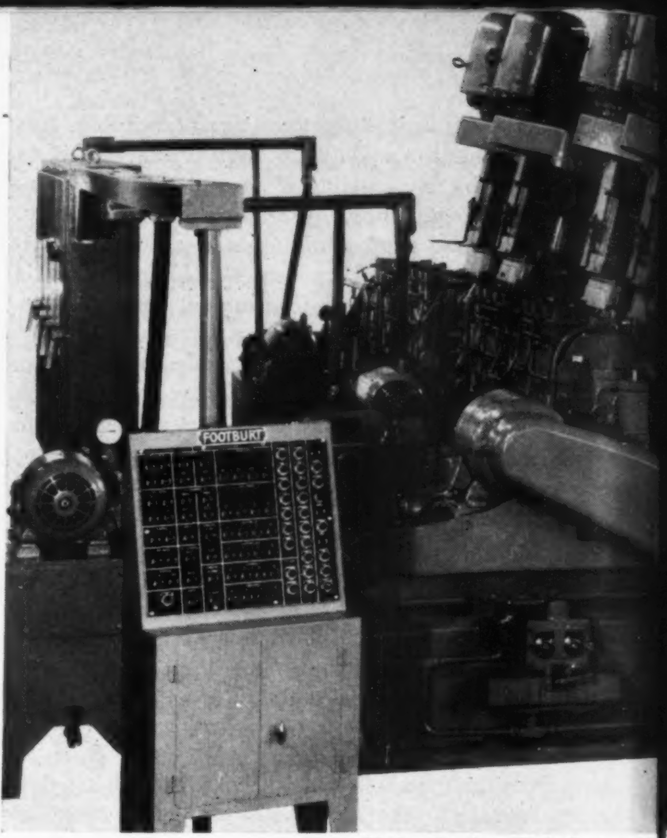


Fig. 10—Left—Typical example of a machine using both hydraulic and electric controls. The main bench-assembled electric controls are conveniently mounted on the right for easy inspection and maintenance. Operator controls are mounted at strategic points

telligent selection of components and circuits. In general, it is more economical to use standard package type controls if possible. For this reason, a catalog knowledge of the available types of basic controls is desirable. TABLE 1 shows a comparative cost chart for 3-phase full-voltage motor starters and TABLE 2 shows a similar chart for reduced-voltage motor starters.

In many cases installation costs such as mounting and wiring of controls may run higher than the price of the controls themselves. In the event a machine requires a grouped control to perform many functions, it is desirable to have a special control panel constructed where the component relays and contacts are factory mounted and wired. Controls, bench-assembled on a panel, usually require less time and labor than components mounted and wired on the machine, *Fig.* 10. Many machine designers overlook labor and overhead costs when comparing the cost of



Photo, Courtesy Foote-Burt Co.

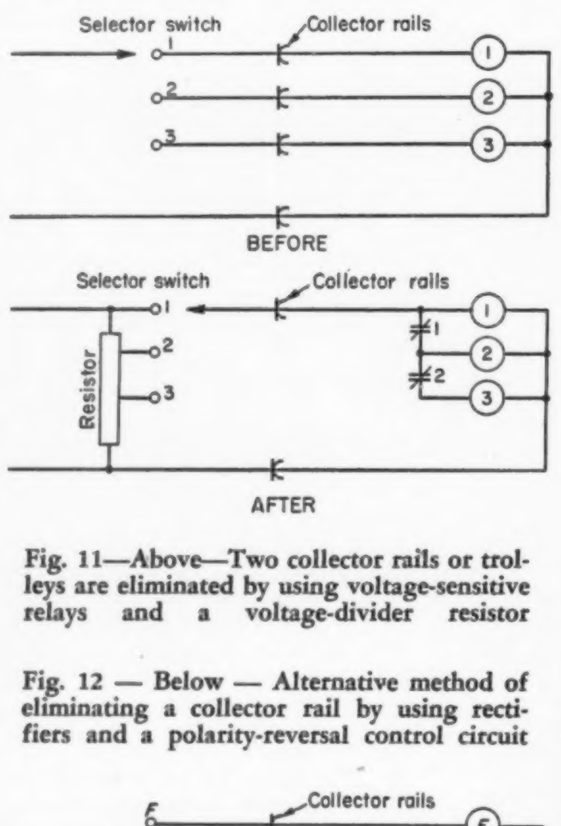
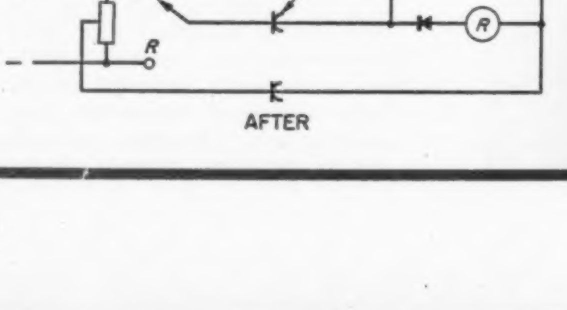


Fig. 11—Above—Two collector rails or trolleys are eliminated by using voltage-sensitive relays and a voltage-divider resistor

Fig. 12 — Below — Alternative method of eliminating a collector rail by using rectifiers and a polarity-reversal control circuit



component control parts vs. factory-assembled controls.

Many times, however, it is necessary to mount the various control components separately on the machine rather than to group them on a panel. Where space is at a premium, such as in battery trucks or portable machines, individual components can be tucked away in various locations. In the process of saving space, however, wiring and installation costs may increase as much as four times. The use of wiring harnesses should not be overlooked in the construction of duplicate controls.

On complicated controls such as those used on automatic machines or processing lines where field adjustments and changes may be anticipated, it is often economical to supply 10 to 20 per cent spare terminals as well as extra relays on the control panels. If they are needed they are available, if not, they are valuable as spare parts.

In dc control circuits, the use of voltage-sensitive relays or polarized relays sometimes eliminates considerable wiring cost. This factor may be involved where control signals originating at one point must be transmitted to a remote moving device employing collector rails. If the additional wiring cost or the collector rail is more expensive than relays required, then schemes such as shown in *Fig.* 11 may be desirable. Here relays having different pickup voltages are used. By means of a rheostat more or less voltage is transmitted to the control panel. The corresponding voltage relay responds. As shown in the "before" sketch the selector switch is turned from position 1 to 2 to 3 to apply voltage to the corresponding relay coil. These coils all have the same voltage pickup and dropout.

In the "after" sketch, when the selector switch is moved to position 1, the maximum voltage is applied

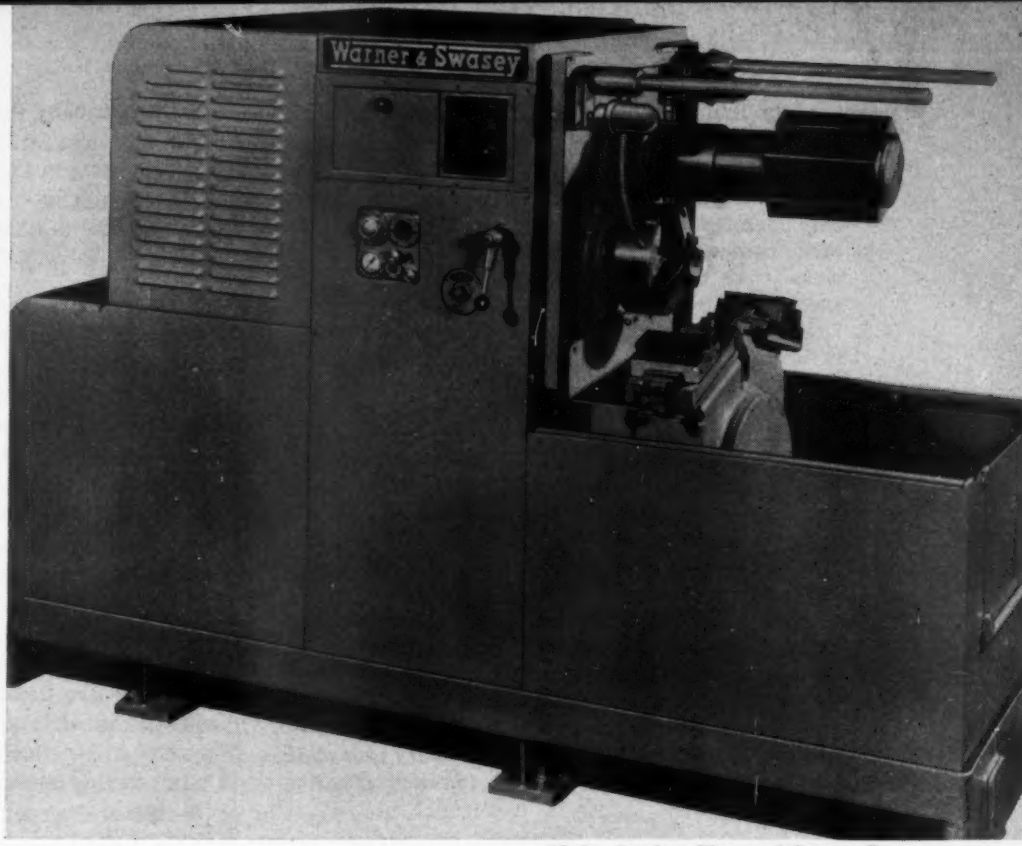


Fig. 13—Left—Multiple-spindle automatic machine with automatic controls and special operator's panel. Indicating lights and pushbuttons provide convenient means for manual operation, the lights indicating sequence of operations and assisting in trouble shooting

Fig. 14—Right—Master switches and all adjusting controls are mounted as an integral part of the machine. The complete control is accessible by removing a side plate on the machine

Photo, Courtesy Warner & Swasey Co.

to the 3 relays. Relay 1 has a coil that picks up at that voltage value. At that instant the normally-closed contact 1 opens to prevent the energization of relays 2 and 3. When the selector switch is turned to position 2, a reduced voltage is applied to the three relays. Relay 1, picked up on the top voltage, does not hold-in on the voltage received from tap 2. Relay 1 therefore drops out and relay 2 is energized. At that same instant the normally closed contact on relay 2 opens to prevent relay 3 from picking up. When the selector switch is turned to point 3, a still lower voltage is applied to the three relays. This voltage is sufficient to pick up relay 3 but not to hold in relay 2 or 1.

It can be seen that two connections from the selector switch to the relays have been eliminated and that, in so doing, the relays must all have progressively lower voltage pickups and dropouts to provide the required voltage selectivity. Various other similar systems can be employed, achieving the same savings in conductors.

Fig. 12 shows a similar technique where relays are polarized by means of dry-type rectifiers. Reversing the polarity causes the opposite relay to pick-up.

Placement of apparatus sometimes determines the type of control to use. Many times a relocation of the control where the type of enclosure is the deciding factor can mean a saving. TABLE 3 shows a comparison of relative enclosure costs. In an explosive-atmosphere application, it may be economically desirable to mount the control remotely and use general-purpose control enclosures in lieu of explosion-proof enclosures.

Operating costs sometimes appear more real to the machine user than to the machine builder. Nevertheless, reputation and repeat sales hinge on the designer's ability to recognize the user's operating costs.

Convenient location and proper controls assist in providing better working conditions for the operator. Careful selection of adjustment features included in the control may save the operator's time. Speed controls and timer adjustments located at the operator's stand mean less moving around. *Fig.* 13 shows a separate control panel housing all the important controls and adjustments that might require attention while the machine is in operation. If a timing period may need to be changed during machine operation, the designer certainly should not use a timer that involves taking the control apart to change a set of gears.

A designer could mount all the control equipment in the base of a machine and thus save the cost of a control cabinet or enclosure, *Fig.* 14. In general, operating costs are minimized if

1. Master controls are conveniently located
2. Control adjustments are accessible and convenient to set, *Fig.* 15
3. Means are provided to quickly change from automatic to manual control. This applies mostly on high-production machines where emergency manual operation would keep production rolling.

In selecting controls, the problem of maintenance must never be overlooked. The machine builder may save money on a particular control device and pass the savings on to the user but, if the user finds that maintenance costs many times the original savings effected, obviously there is no advantage.

It would be ideal to employ controls that require no maintenance. Many devices such as dry-type rectifiers, transformers, etc., may appear to require no attention. However, maintenance procedures such as blowing off dust to prevent overheating of parts are necessary.

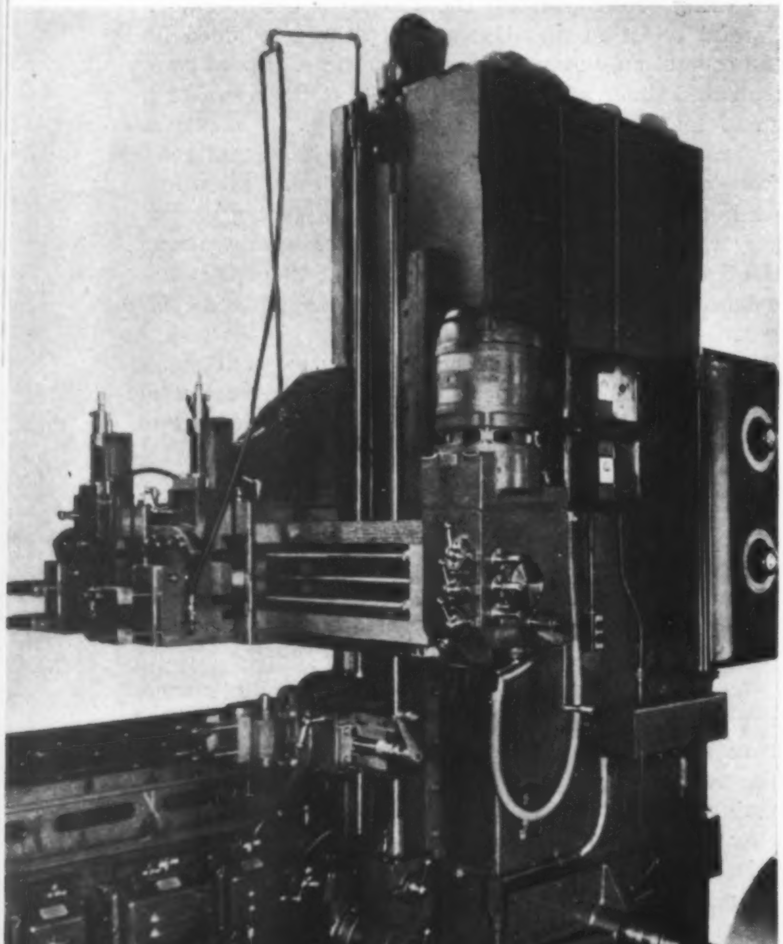
Items to look for when designing to reduce mainte-

nance costs include the following considerations:

1. Use controls with operating life consistent with the application. Obviously a device good for 10 million operations is not necessary if the device only operates once a month
2. Pick components with contact coils and other parts that can be readily and conveniently inspected and replaced
3. Design panel layouts so that troubles can be quickly located and repaired. Sometimes the additions of indicating lights to show what devices are operating or not operating aid in locating troubles
4. If possible, standardize on the components on a control panel. Using all the same type of relays, etc., reduces the number of different types of components with which the maintenance man must become familiar
5. Use the minimum number of components consistent with good practice. In other words it is better to use additional interlocks on the contactor rather than an extra relay. On size 1 to 3 contactors it is less expensive to use interlocks on the contactor rather than auxiliary relays. On size 4 contactors and larger it is less expensive to use the contactor and an auxiliary relay. It should be remembered that four auxiliary contacts are usually the limit on most contactors
6. On duplicate machines, mount the control components in the same relative position on the panels
7. If possible, use plug-in type components where it is known that the component life is questionable or the device is delicate.

Fig. 15 — Controls, pushbuttons and limit switches are mounted conveniently on this Cleveland open side planer

Photo, Courtesy The Cleveland Planer



Depreciation of control ties in closely with maintenance. Wearable parts such as contacts, etc., are recognized as requiring replacement before other parts of the control. In general, if the cost of the control relative to the machine is high, then the depreciation rate should approach that of the machine.

Obsolescence usually is not involved in machine applications because controls are designed more from the functional rather than the style or appearance point of view. Controls are designed to perform a certain job and, being usually hidden or mounted in enclosures, do not detract from any appearance effect of the complete machine. Most control components are designed to have a long life and styling is not their basic requirement.

On some machines, however, outward-appearances and styling must change every few years to keep up-to-date. For instance, on home workshop and portable tools it is desirable to enclose as much of the control as possible. Knobs and projecting handles should be detachable so that these items can be restyled without altering the rest of the control.

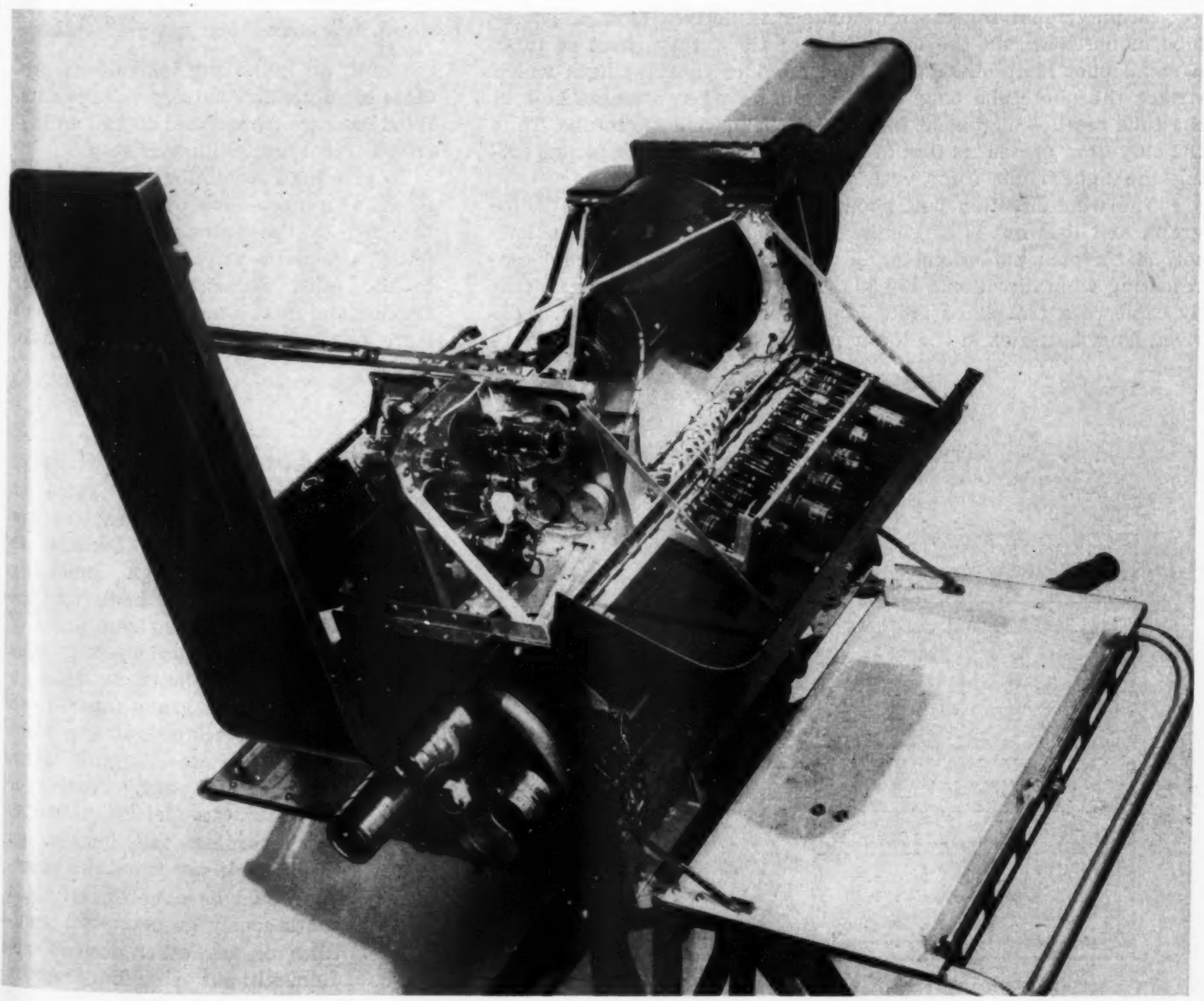
Machines involving many automatic functions may employ hydraulic, pneumatic, electric motor, or solenoid actuators. If hydraulic, the controls may be through limit switches, electric solenoids or valve limit switches. The choice may then hinge on whether it is more expedient to convey the intelligence via electric conductors or piping. The technique of knowing when to convert from electrical to mechanical or hydraulic or vice versa is necessary to develop a good working combination. Sometimes a combination as on the machine shown in *Fig.* 10 may be used.

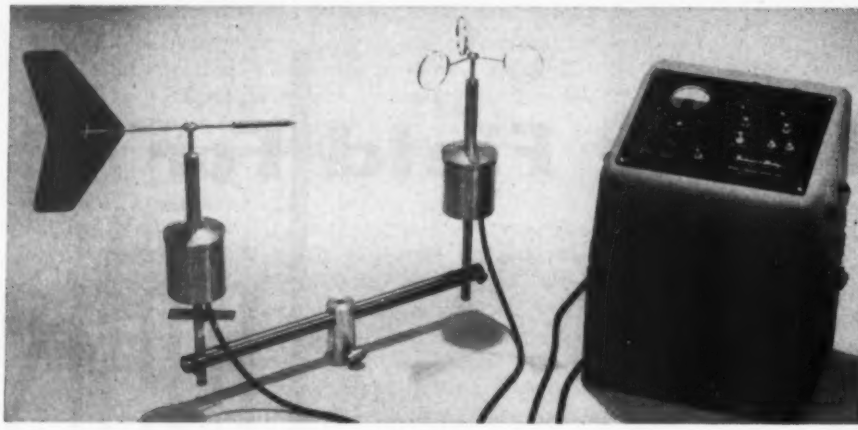
With the advancements in all fields, a designer who has equipped his entire machine with hydraulic control valves, piping and actuators may save a considerable portion of his control costs by simply replacing the control valves and extensive piping to the actuator with a compact electric control switch and wiring to an electric solenoid at the hydraulic actuator. It may be possible to group the entire power mechanism and eliminate all other control piping in this fashion. The general rule is to use the simplest combination of units involving parts that require the least amount of adjustment, maintenance and replacement.

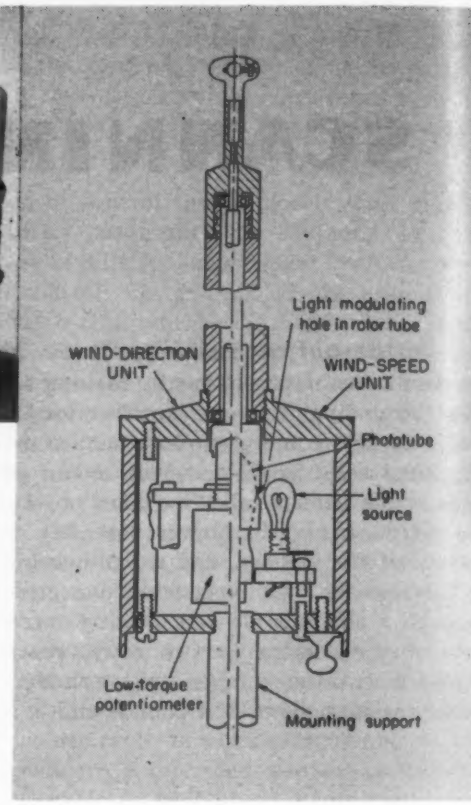
No doubt there are many other "tricks of the trade" in arriving at the most economical control. Some unique circuits have been or are being designed which become exclusive with a particular builder. Sometimes at first glance the layout of a control looks like the best buy. Looking at it from the operation and maintenance point of view may bring out some undesirable features that could be eliminated readily. In general there is no substitute for a systematic and complete overall analysis of a control problem.

SCANNING the Field For Ideas

Inside-out accessibility of the television camera shown below facilitates maintenance by making all components easy to service. This "exploding" type of construction of RCA's new image orthicon studio or field camera employs subassembly construction of focus and alignment coils, yoke, and slide mount with plug-in electrical connections. The camera also includes provision for a filter disk back of the turret, a plug-in blower assembly which is removable from the bottom of the camera, and a ball-bearing drawer-slide mount for the coil assembly. All electrical connections to the camera are made through a single cable and plug. Controls for the circuits are on the rear of the camera in two rows, protected by two hinged covers. Styled in two-tone umber gray wrinkle finish with chrome trim, the camera weighs about 110 pounds and is approximately 22 inches long.





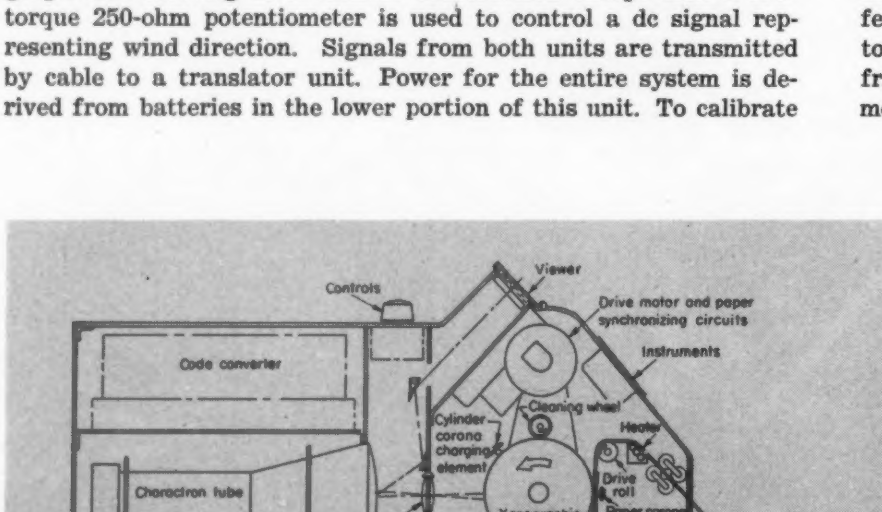


Minimizing effects of friction and intertia through the use of electronic sensing elements and lightweight parts, the wind-direction and speed measuring unit shown above is capable of accurate recordings at very low thresholds. Designed by Beckman & Whitley Inc. for use in light winds to study smog conditions, agricultural pollination, flood forecasting, etc., the requirements of the system are low stall point, high accuracy, portability and field reliability. The anemometer unit shown in the right half of the sectional drawing, right, has a linear response from less than one mile per hour to 30 miles per hour.

Output signal for the anemometer is derived from a phototube mounted within the lower part of the rotary shaft or tube. A small pilot lamp outside the tube provides constant light which strikes the phototube once each revolution when a single hole in the tube reaches alignment between the lamp and phototube. Thus the only drag present is that of the precision ball bearings supporting the lightweight rotor with plastic cups.

The wind-direction unit shown at the left in both the photograph and drawing is of similar construction except that a low-torque 250-ohm potentiometer is used to control a dc signal representing wind direction. Signals from both units are transmitted by cable to a translator unit. Power for the entire system is derived from batteries in the lower portion of this unit. To calibrate the unit, an indicating instrument provides the necessary battery voltage data. Wind data are transcribed on two spring-driven recording milliammeters.

To give high resolution to the recorded data, a keep-alive output circuit is included in the translator unit. This feeds a square wave of low voltage to the pens, overcoming pen-to-paper friction and inertia and making the pens more responsive to the applied signals.



Automatic printing of transmitted data at rates as high as 10,000 characters per second may soon become an eventuality through combining the Charactron cathode-ray tube with the Xerography process of dry printing developed by the Haloid Co. Shown at left is a schematic diagram for such a process developed at the Consolidated Vultee Aircraft Corp. by J. T. McNaney, inventor of the Charactron electronic tube. By recording the images on the cathode-ray tube, the printing would be done directly and continuously on newsprint, multilith or any other desired medium without using film or other

intermediary chemical processing.

This unique design of cathode-ray tube employs a matrix containing character-shaped openings located between the electron gun and the fluorescent screen at the viewing end of the tube. A stream of electrons, selectively directed through the matrix openings, produces a shaped beam that provides a presentation of characters on the screen of the tube. An electrostatic deflection system is utilized for the character selection of the matrix, and either electrostatic or electromagnetic deflection is used for placing the images on the viewing screen. In this manner, the proper sequence of applied deflection voltages selects and positions the matrix characters on the screen.

These characters are projected on an electron-sensitive printing cylinder. Powder for the printing process is sprinkled on the cylinder and is held only on the sensitized portions corresponding to the image projected from the tube. This serves to print on the paper which is fed from a roll to contact the cylinder. The printed paper is then cut and fed into a receiving bin as illustrated in the sketch for collecting the sheets in sequence or for removal by an operator.

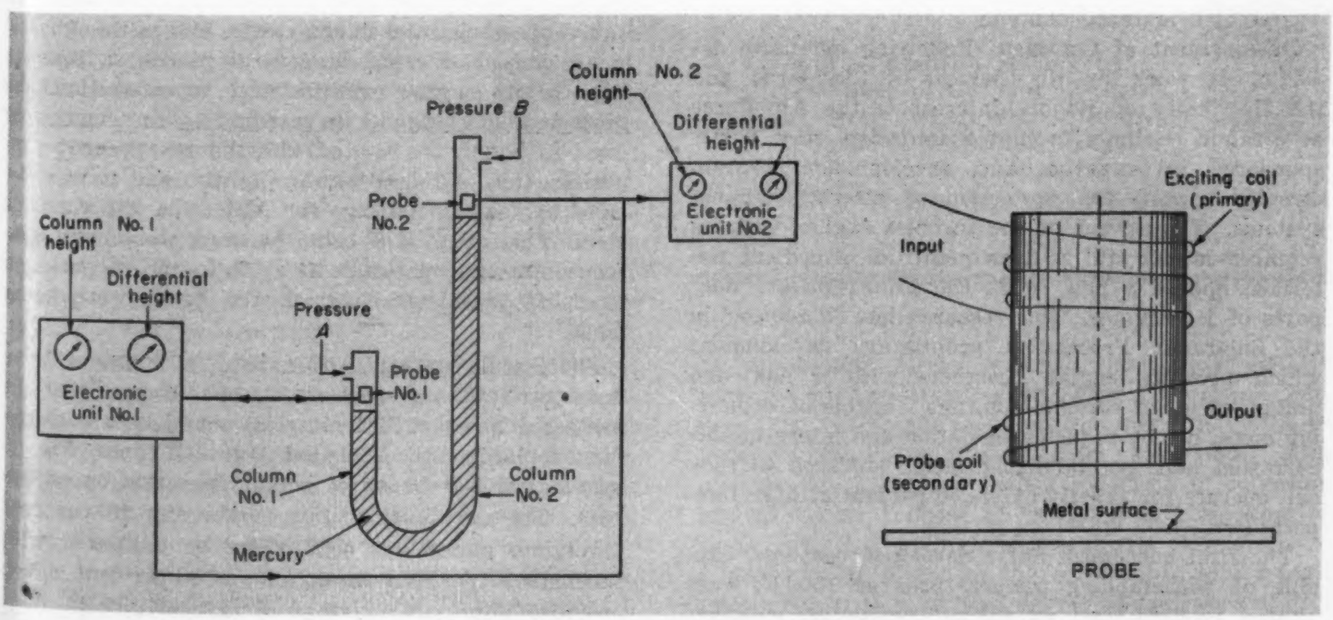
This reproducing equipment, referred to as a Charactron high-speed printer, has a printing speed of approximately 20 inches of paper per second and will be useful for voluminous recording at high speed.

Precision measurements of pressures within 0.0005-inch of mercury are obtainable with the electronic manometer illustrated schematically, below. This system utilizes high-frequency mutual-inductance probes to sense the height of mercury in the columns without touching it. Since no float or electrical contact is required, disturbance of the mercury surface is minimized and accuracy of reading is increased. The new technique was developed by M. L. Greenough and W. E. Williams of the National Bureau of Standards to meet special pressure-measurement requirements.

Above the mercury surface in each column is mounted a mutual-inductance probe consisting of a primary and a secondary coil as shown in the sketch below. When the primary coil is supplied with constant radio-frequency current, the voltage induced in the secondary varies with the mutual inductance or coupling between the two coils. This inductance varies with the proximity of the mercury surface; the closer the mercury surface is to the probe, the greater is its shielding effect and the less the output voltage. Thus, this voltage becomes an index of probe-to-mercury distance and can be used to indicate this distance with high precision.

Connected to each probe is a zero-center microammeter calibrated to indicate variations in the height-difference of the two columns. When these meters read zero, the probe-to-mercury distances in the columns are identical and the differences in the probe heights is equal to the difference in mercury heights. With this form of null indication, the mercury columns may be reset accurately to the same differential height, assuring reproducible pressures. Since the differential height meters have a measurement range of only 0.04-inch in the present arrangement, individual-height meters with a range of 0.3-inch are provided to facilitate adjustments of the columns.

Primaries of the two probes are excited by a 480-kilocycle amplitude-regulated oscillator. A vibrating relay compares the outputs of the pickup secondaries by switching first to one and then to the other. The difference in output is amplified, rectified and applied to differential-height meters.



CERAMIC COATINGS

DEVELOPMENT of better heat-resistant alloys, capable of working at the high temperatures of the modern jet engine, has advanced rapidly in recent years, but this advance is being threatened by an insufficient supply of such metals as cobalt, columbium, tungsten, nickel, and chromium. Consequently, major research now is being directed toward conservation rather than increased use of these metals. Of major importance to this conservation program are ceramics, which promise to not only extend the service life of currently used heat-resistant alloys but also allow substitution of alloys with less critical material content.

Development of Coatings: Following extensive development work by the Bureau of Standards and the University of Illinois, interest of the Air Force in ceramic coatings prompted initiation of a Solar-sponsored investigation and development program directed toward the protection of aircraft exhaust systems. The advent of the turbojet engine, with its requirement for still greater quantities of critical materials, opened a new field—the protection of "hot" parts of jet engines. This research has culminated in the Solaramic Process, a proprietary development which provides engine designers with a new and unique series of ceramic coatings, capable of enhancing metal life by reducing oxidation and intergranular corrosion and by stabilizing metal surfaces so they can operate for greatly extended periods at high temperatures.

The first successful Solar developed coatings, capable of withstanding temperatures of 1600 F, were applied to mild steel jet engine combustion chamber liners late in 1947. The first liners were fabricated of SAE 1010, and were Solaramic processed with some little difficulty, as at that time no coating production facilities were available. Tests on these liners indicated that the coating was satisfactory. However, the 1010 lacked sufficient strength at the operating temperatures and failed by collapsing after 12 hours of accelerated engine testing. One of these liners is shown in *Fig.* 1.

With a reduction of critical alloys still in mind, Solaramic coated liners made of SAE 4130 were next tested. These parts successfully completed over 170 hours of accelerated engine tests, and, although hot spots caused warping in several places as seen in *Fig.* 2, the engine manufacturer reported that the protected liners would be satisfactory for emergency use. Although the coated 4130 liners appeared promising, they did deteriorate slightly, and it was decided to develop coatings for AISI type 321 stainless steel. This alloy, if it could be used, would still conserve strategic materials relative to the Inconel and type 310 stainless of which the liners were being made.

Successful coatings for type 321 stainless were developed, and numerous engine tests showed that the protected liners of 321 material would be a satisfactory replacement. A coated type 321 liner, *Fig.* 3, has logged 580 hours of actual operation on an engine. The use of this alloy, containing 18 per cent chromium and 8 per cent nickel as compared with Inconel's 17 per cent chromium and 80 per cent nickel, provides impressive savings of critical nickel.

offer direct savings in critical alloys and extended service life of high-temperature parts

By John V. Long
Solar Aircraft Co.
San Diego, California

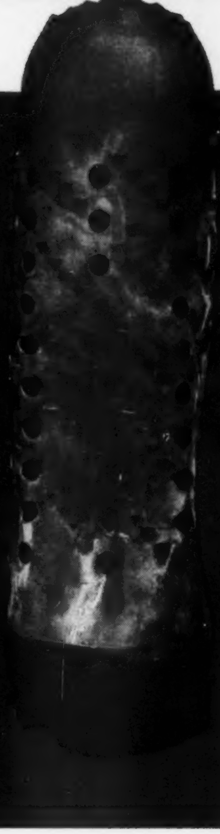


Fig. 1 — Left — Ceramic coated mild steel (SAE 1010) combustion chamber liner for a jet engine withstood high temperatures but high-temperature strength of the base metal was inadequate and the liner buckled and failed within 12 hours

For a clearer understanding of the possible savings, a comparison of the percentages of the critical elements contained in several well known high temperature alloys is:

Alloy	Co	W	Cb	Cr	Ni
19-9DL	..	1.25	0.4	19	9
N-155	20	2	1	20	20
Inconel	..	..	..	17	80
Type 310 stainless	..	..	..	25	20
L-605	50	15	..	20	10
Type 321 stainless	..	..	..	18	8

Solaramic processed parts fabricated of type 321 have been used in a number of cases to replace those normally fabricated of the other listed alloys.

Advantages of Ceramic Coatings: A satisfactory coating offers a number of advantages. It protects the base metals against the corrosion and oxidation attack of combustion products at high temperatures. It provides a smooth, vitreous surface which offers a minimum resistance to the flow of gases, thus decreasing friction losses and reducing carbon and other combustion product accumulations. It prolongs the fatigue life of the base metal.

Although thin ceramic coatings in general do not provide appreciable insulation, by adjusting emissivity it appears possible to affect materially the heat flow through the sheet metal parts. For example, a sheet metal part with a low emissivity coating on the inside tends to reflect the heat away, while a part with a high emissivity coating on the outside tends to radiate the heat which passes into the metal.

A satisfactory coating increases fatigue strength by eliminating stress raisers. This is particularly true at high temperatures with vitreous ceramic coatings. The coat tends to reduce the magnitude of temperature gradients arising from hot spots. This phenomenon, combined with a reduction of corrosion and oxidation, reduces the warping and cracking of parts subjected to high temperatures, *Fig.* 4.

The coating increases the service life under high temperatures to a marked degree as indicated in *Fig.*

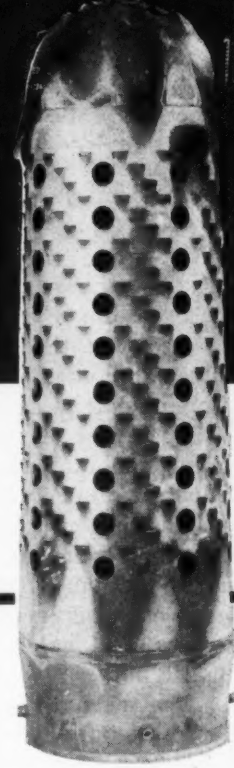


Fig. 2—Above—Ceramic coated chromemoly steel (SAE 4130) combustion chamber liner gave 170 hours service and was accepted as an emergency substitute for standard Inconel liners

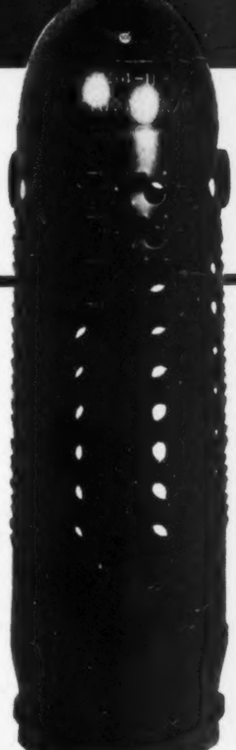


Fig. 3 — Right — Solaramic Processed liner of AISI type 321 stainless steel successfully withstood 580 hours of engine operation, and it is considered a desirable substitute for the uncoated Inconel

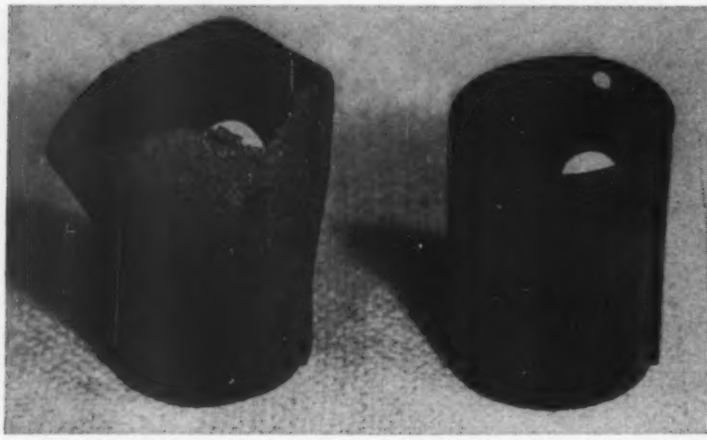


Fig. 4—Two cylinders of 321 stainless cyclically heated for 15 minutes at 1900 F, then cooled in air for 15 minutes, over a 40-hour period. Effects of "hot spots" on coated tube, right, is nil, while uncoated tube, left, has deteriorated badly

5, which shows the results of laboratory oxidation tests. It will be noted that the coated 321 displays no measureable effects, the uncoated Inconel picked up weight slightly from oxidation, and the uncoated type 321 lost almost 18 per cent of its initial weight in oxides. The excellent oxidation resistance of the coating is strikingly illustrated in *Fig.* 6.

The most important advantage of a ceramic coating in view of the present shortage of strategic metals is that it allows the substitution of alloys such as type 321 stainless steel for Inconel, N-155, 19-9DL, and L-605. However, the substitution of ceramic coated 18-8 steels for higher strength alloys must be made with care. The strength factor at operating temperature is the most important consideration and may be used to determine if a coated low-alloy steel will provide satisfactory service. An example of this successful substitution is shown in *Fig.* 7, a Solaramic processed type 421 turbohood, a part originally made of N-155. This hood now has over 400 hours of engine operation test without deterioration, clearly indicating that the 321 has sufficient strength.

At the present time practically all high-temperature ceramic coatings are being applied to aircraft parts such as combustion chamber liners, transition liners, nozzle boxes, turbohoods, and jet tailcones. However, a number of commercial applications appear feasible, including protection for steam turbine parts, gas heater reflectors, pipe lines carrying high pressure steam or corrosive fluids, acid tanks, and the like.

Design for Coating: The ceramist has encountered many difficulties in applying his coatings because the design engineer has not recognized the advantages of such protection and has failed to incorporate a coating in his original plans. This is particularly true where close tolerances are demanded. For example, in turbine rotor buckets the cold nonoperating clearance of as much as 0.020-inch between the blade tip and outer ring decreases to approximately 0.005-inch when the unit is in operation and the blades

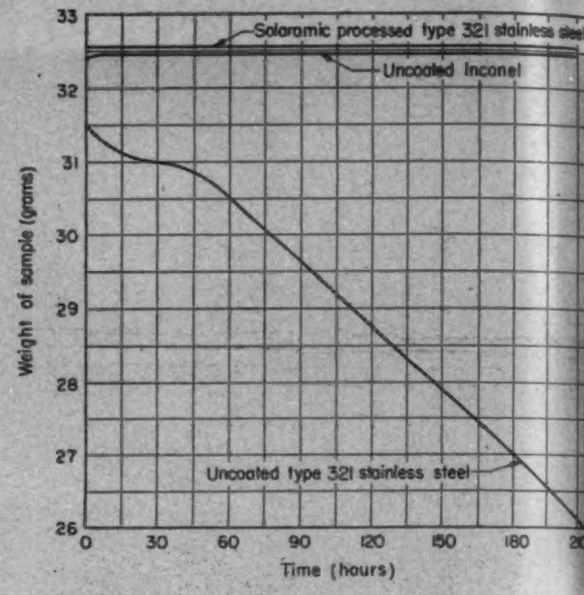


Fig. 5—Above—Comparative oxidation rates of coated and uncoated metals. Samples tested at 1700 F, cooled and weighed at 15-hour intervals

Fig. 6—Below—Both screens, type 302 stainless steel, were heated at 1600 F for 10 hours. Uncoated screen, right, has oxidized badly

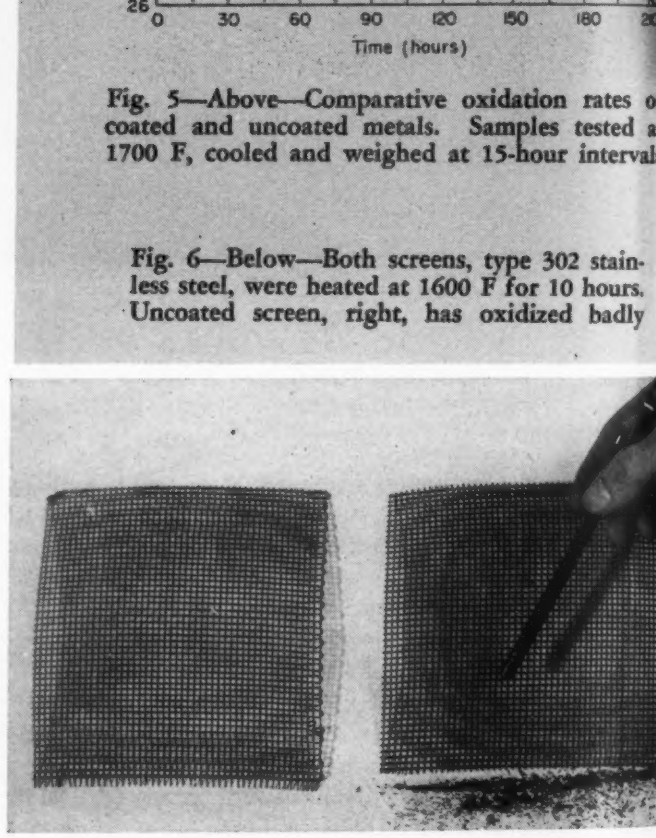


Fig. 7—Below—This turbohood, type 321 stainless with a Solaramic coating, has logged over 400 hours of operation on an R3350 engine with no evidence of deterioration. This part previously had been fabricated of uncoated N-155 alloy

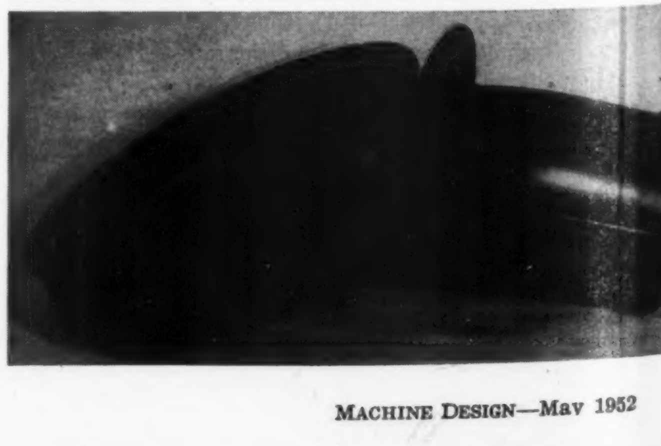


Fig. 8—Actual coating procedures: right, man is spraying an exhaust manifold section with Solaramic slip; left, the sprayed sections are being placed in a 200 F infra red drying booth; background, coated turbosupercharger nozzle boxes are coming out of the firing oven, ready for final machining

expand under the influence of centrifugal force and high temperature. Although the coating as applied is seldom over 0.002-inch in thickness, this fact must be taken into consideration in designing for close running clearances, slip fits, and similar conditions.

Physical Characteristics of Coatings: Although this new high-temperature ceramic art has many unique features, it has descended from the porcelain enameling trades and a number of standard methods have been adapted from the parent industry. In general, the better properties of enamels and porcelains are those required of high-temperature ceramics. The coating should be thin, refractory, and adherent enough to withstand the operating and handling conditions to which it will be subjected. For low-alloy applications, it should bond properly to mill-run materials, rather than necessitate the use of premium-grade steels such as normally are used in porcelain enameling. It should be capable of covering minor imperfections and scale inclusions, always present after the processing cycle.

Firing and firing temperatures are of extreme importance. The coating should be versatile enough to fire on a class of alloys, rather than a specifically designated alloy. For example, a coating designed for type 321 stainless should give acceptable results on all the AISI 300 and 400 series stainless steels and the superalloys. It must have a broad firing temperature range, for use on standard subassemblies of various metal gages and extreme complexity of shape.

It is important that the coating be capable of withstanding temperatures higher than those required for the firing-on process. Since many aircraft parts must maintain close tolerances, it is necessary that warpage be kept at a minimum. Low temperatures mean less warpage; therefore it should be possible for the coating to be burned-on at as low a temperature as possible. Despite low-temperature firing, however, it is mandatory that the coating withstand temperatures to be encountered in actual operation.

Another obviously necessary property is that the coating should not reboil, spall, or fishscale under any conditions likely to be met in operation. It should also have high mechanical and thermal shock resistance and excellent adherence so it will not peel off under operating conditions where vibration, high thermal stresses, and exaggerated thermal shock conditions are encountered. A final requirement is that the coating should have no deleterious effects on the base metal. That is, it should not attack the base metal by intergranular corrosion or by pitting the metal at the metal-coating interface.

Borrowing from the experience of the porcelain enameler, it was found that the ceramic slip should not contain excessive di-valent or tri-valent soluble ions, as these have a strong flocculating effect which makes necessary the addition of large amounts of pyro (sodium pyrophosphate) or citric acid, thus causing a rapid deterioration. Too, the slip must be workable and should not age excessively on standing.

Components of the frit must be insoluble, it was discovered, as a soluble frit produced large crystals which make dipping and spraying extremely difficult unless a frequent screening procedure is adopted.

Processing of Coatings: With this evaluation of the properties required of a specific coating, it is possible to proceed with the steps of developing the slip and firing it on the part.

Chemical ingredients are weighed in the proper proportions and thoroughly mixed dry, preferably in a "V" type machine, although the dry cone mixer is used to some extent. This mix is smelted at a temperature of from 1500 F to 2800 F, depending on the constituents, until quiescent. The molten glass then is poured into a cold water tank (the fritting operation), thus causing the mass to fracture such that it can be milled easily to the required fineness.

This frit is now pulverized to a 10-mesh screen size

and, with water, clay, and other mill additions, is ground in a ball mill to a fineness such that not more than 0.5 gram of a 50-milliliter sample of a slip remains on a 325 mesh screen.

Before a workpiece is sprayed or dipped, it is subjected to a cleaning process which includes degreasing and either sandblasting or acid pickling. It is then sprayed with or dipped in ceramic slip and thoroughly dried. In the case of base metals of stainless steels and the super alloys, drying in ambient air is practiced, but the drying of mild steel parts must be expedited in ovens at up to 200 F as a precaution against oxidation. If permanent identification of the part is required, at this point identifying markings can be sprayed through a stencil on the base coat with a slip of different color.

The coat now is burned-on at firing temperatures of from 850 to 2200 F over periods ranging from several minutes to as much as an hour, depending upon the nature of the coating and the part. The temperature is dictated by the type of coating, and the time is that required to bring the base metal mass to temperature. Thus a thin-gage sheet metal part would need only a short firing period, while a casting or heavy-gage workpiece would require a longer soak at temperature.

While, in general, the firing is followed by cooling in air, there is a series of heat-treatable steels, including such alloys as SAE 4130 and NE 8630, which must be water or oil quenched and drawn to regain the ductility lost during the firing process.

Unless a top or second coat is required, the part now is ready for final machining and assembly. Common Solaramic coatings are single coats, but double coats are sometimes prescribed for special functions such as antigalling in high-temperature service. If a second coat is necessary, the workpiece is sprayed or dipped again, and refiring follows.

Future Low-Alloy Coatings: With completion of a number of exacting field tests at full rpm engine operation by Allison, General Electric, and Air Materiel Command on coated type 321 components, research has again turned to the improvement of low-alloy coatings. Original Solar coatings which successfully protected the SAE 1010 and 4130 alloys were unique and quite different from the ordinary porcelains and enamels developed by Government-sponsored University programs. But they contained strategic materials which, it is felt, must be eliminated since the coatings developed for the stainless steels and higher alloys are formulated completely without critical metals and oxides.

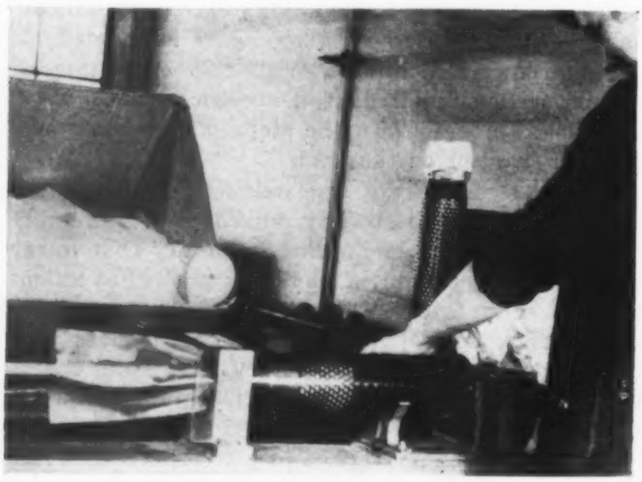
At the present time extensive tests are being run with rotor buckets and stator vanes of Timken 17-22A alloy, and hot parts of NAX and other low-alloy steels coated with experimental Solaramics which do not contain critical materials. However, additional work is required to provide satisfactory coatings with properties comparable to those that have been developed for the stainless steels and super alloys. Success in this endeavor will release large quantities of highly strategic metals for more essential work.

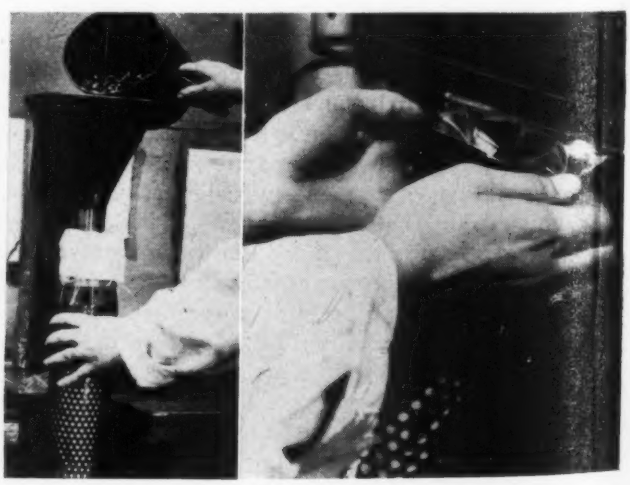
Plastic Liners Keep Powder Dry

RECOILLESS rifles have placed unprecedented firing power in the hands of U. S. infantrymen. But cartridges for these rifles, having large perforations in the case to permit exhaust gases to escape without kickback, must be protected against all kinds of wet weather and humid conditions.

Polyethylene plastic film, which is chemically inert and maintains its flexibility at low temperatures, is assigned this job. Liners made of the Bakelite plastic, sealed to a thick base of the same material, are inserted into the perforated cartridge case, smokeless propellant powder is then loaded into a bag inside the liner, and the open end of the liner is heat-sealed.

When the round is fired, heat of the reaction burns the powder bag and vaporizes the polyethylene liner. Exhaust gases then flow out the shell-case perforations through breech vents, eliminating recoil.





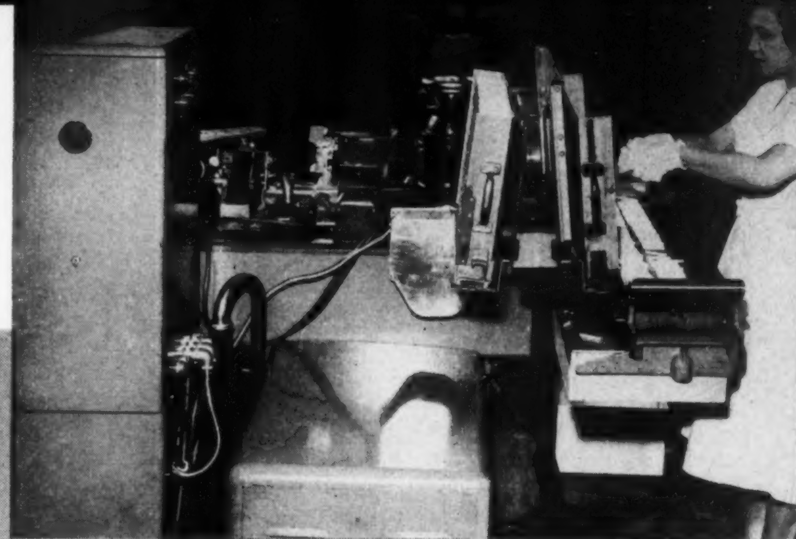


Fig. 1—Cigarette machine in which the bypass form of variable-speed drive is applied to improve cigarette uniformity through better tobacco-feed control. Cabinet at left houses electronic controls for the drive which is located back of the cabinet

Bypassing Power in *Variable-Speed Drives*

How accurate control through critical speed ranges in machine drives can be accomplished economically by proportionalizing the load torque in a variable-speed unit and planetary gear combination

By L. A. Graham and S. Gilman

Graham Transmissions Inc.
Milwaukee, Wis.

American Machine and Foundry Co
Raleigh, N. C.

BUILDERS of machines requiring variable speed control have long been attracted by the possibility of "bypassing" most of the required power through use of a differential gear train while transmitting only a small part of it through a variable-speed unit. Thus, a much less costly transmission can be used—say a 1-hp variable unit in a 10-hp drive, or a 5-hp unit in a 50-hp drive. Unfortunately, this can be done only in limited ways and under special conditions, but for those special cases, to be explained in this article, the savings may be great and the performance improved as compared with alternative methods.

In an article in MACHINE DESIGN by one of the authors (November, 1946) it was pointed out that—in spite of the "wishful thinking" of many designers—this method is not at all applicable where *wide* ranges of output speed are required. This was explained by assuming the use of a 3 to 1 range variable unit in conjunction with a differential where it was desired to obtain all ranges of speed from maximum to zero. Because of the phenomenon of circulating power it was shown that such a combination actually required a $1\frac{1}{2}$-hp variable-speed transmission to do a 1-hp job.

However, the situation is very different where the conditions are completely reversed, that is, where a *wide* range variable-speed transmission is used in conjunction with a differential on a job requiring only a *small* range of speed variation, but at extremely high accuracy, and particularly on applications calling for automatic speed control. Drives of this kind are used extensively in machines such as paper calenders, steel sheet rolls, winding operations where a tension-free loop must be maintained, highly accurate feeders, etc.

Recently the authors collaborated in applying the "bypass" plan, as it may be termed, to the feeding

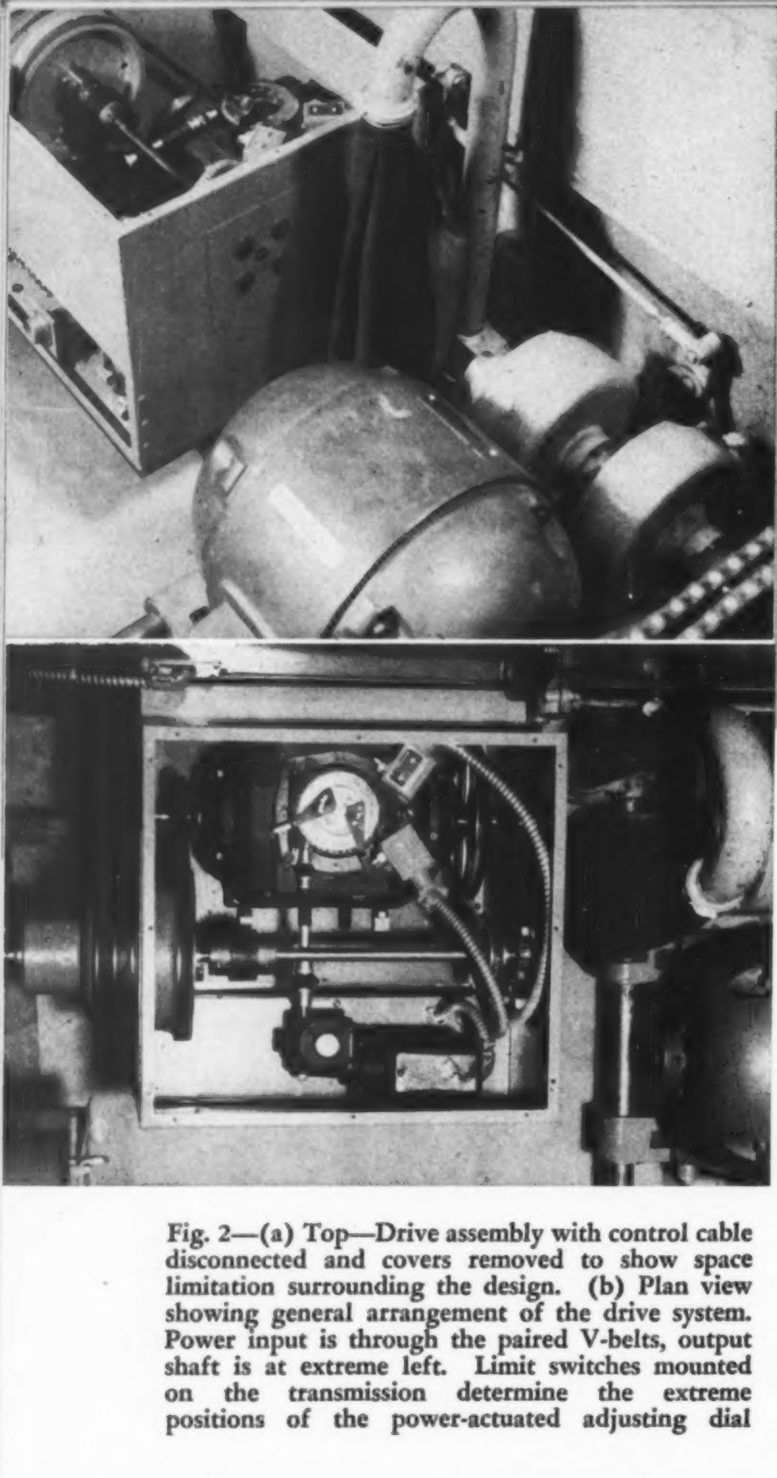


Fig. 2—(a) Top—Drive assembly with control cable disconnected and covers removed to show space limitation surrounding the design. (b) Plan view showing general arrangement of the drive system. Power input is through the paired V-belts, output shaft is at extreme left. Limit switches mounted on the transmission determine the extreme positions of the power-actuated adjusting dial

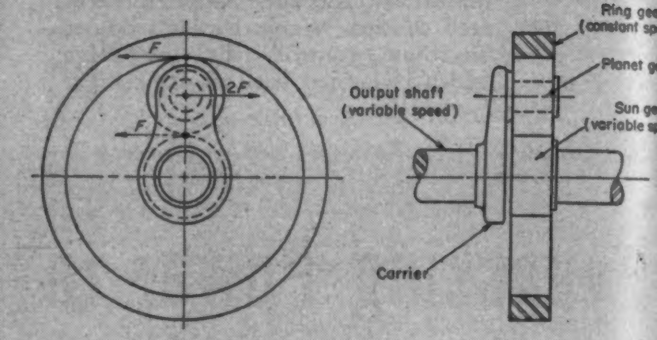


Fig. 3—Basic elements of the geared differential used with the variable-speed transmission shown in *Fig.* 2

of tobacco in a cigarette-making machine, *Fig.* 1. Design of this drive unit, *Fig.* 2, will be discussed for the purpose of illustration. The problem here was to design for existing cigarette-making machines a means of improving the tobacco feed, so as to get more uniform cigarettes with the right amount of tobacco in each, regardless of inevitable variations in character or composition of the tobacco, moisture content, etc. Control of the tobacco feed was to be entirely automatic, instantaneous, and accurate near perfection.

The power requirement was approximately one hp and the speed variation required to accomplish the desired purpose was ten per cent above or below a nominal speed of 600 rpm, in other words a range of speeds from 540 rpm to 660 rpm. Since the drive to accomplish improved feeding was to go on existing machines, space was at a premium which led to the question: Can the job be done without the cost and space requirement of a one-horsepower variable-speed transmission of high innate accuracy and if so, how? To get the answer, consider a planetary gear differential coupled in parallel with a variable-speed transmission and analyze the power flow diagrammatically. Although the output speed range required is to be only 20 per cent, a variable-speed transmission having full speed range from top to zero, such as the Graham, will be assumed.

In the differential, *Fig.* 3, the ring gear is driven at constant speed—equal to the mean output speed, which in this case is 600 rpm. The sun gear is driven by the variable-speed transmission. The planet gears, of which there are usually three, are mounted on a carrier that is connected to the driven shaft.

For the first calculation it will be assumed that the sun-gear pitch diameter equals the planet-gear pitch diameter. The ring gear then has three times as many teeth as the sun gear (the differential being defined as having a 3 to 1 ratio). If the total force on the planet-gear bearing is $2F$, then the corresponding force at the ring gear and sun gear contacts with the planet is F in each case. The output torque is obviously $2F$ times $2 = 4F$, the torque on the ring-gear shaft is $3F$, and the torque on the sun-gear shaft is F. If the sun gear is turned by the variable-speed transmission at 600 rpm and if the output speed (carrier speed) is also 600 rpm, then when operating at mean output speed, all gears in the differential act as if they were locked together. Under this condition, the power input to the sun gear from the variable-speed unit is only one-fourth of the delivered power.

To determine the speed variation of the sun gear shaft required to change the machine speed from 540 rpm to 660 rpm, it is necessary only to add to or subtract from 600, a figure equal to four times the desired output speed change. For instance, to increase machine speed from 600 to 660 rpm, the speed of the

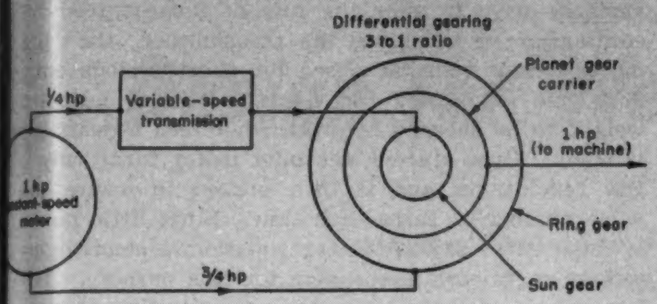


Fig. 4—Power flow diagram shows how the bypass system makes possible limited speed regulations with a less-than-full-capacity variable-speed transmission

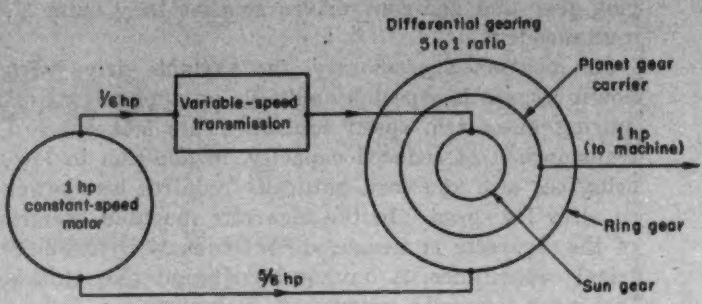


Fig. 5—Power flow digram showing distribution of 1-hp in a bypass arrangement with 5 to 1 ratio differential gearing

sun gear must increase from 600 to 840 rpm. Similarly, to reduce machine speed from 600 to 540 rpm, the sun-gear speed would be reduced from 600 to 360 rpm. Thus a utilized ratio of 840 to 360 or 2$\frac{1}{3}$ to 1 in the variable-speed unit gives the desired range of output speed 10 per cent either side of the mean. The power flow in this system when transmitting 1 hp is shown in the diagram, *Fig.* 4.

It is clear by analogy that if a differential were used with ratio between sun gear and ring gear of 5 to 1 instead of 3 to 1, the power flow would be as shown in *Fig.* 5. This, of course, reduces the power requirement in the variable-speed unit to 1/6 hp while increasing the speed-range requirement from 2$\frac{1}{3}$ to 1, to 4 to 1.

Practical Considerations

Taking the extreme case where a range all the way down to zero is used in the variable unit, for the same requirement of ± 10 per cent variation in output speed, the variable drive then delivers an infinite range from 0 to 200 per cent of average, the differential ratio becomes 9 to 1 and only 1/10 of the output power goes through the variable unit. However, a 9 to 1 differential is not a practical choice. More logical use of a range down to zero in the variable unit would be with a 5 to 1 ratio differential, as in *Fig.* 5, to give a range in the driven shaft 16.66 per cent above and below a desired mean. This would still reduce the power requirement in the variable-speed unit to one-sixth the total requirement.

The additional power required at high output speed must come through the variable drive if the load is constant torque. At 660 rpm the power required is 1.1 hp with 0.75-hp coming from the gear drive and 0.35-hp through the variable-speed unit. Similarly, at low output speed, the gear drive still transmits 0.75-hp while the variable-speed unit transmits 0.15-hp of the total 0.90 hp requirement.

So long as the output speeds remain in their relative proportion, the increments of load on the variable-speed unit will be the same. Regardless of the proportion of power supplied by the variable unit at the mean speed, because of the geared differential, the change in power requirements at the various speeds must be supplied by the variable-speed unit. In the preceding example where the output power range is ± 10 per cent, the 9 to 1 differential is the extreme limit. This would supply zero power at the low output speed and would operate at zero speed. Larger ratio differentials would operate negatively at the low speed, and direction of rotation would be reversed. Therefore, practical limits should be observed.

An important advantage in a combination of this character is the accuracy of speed setting. If the setting on the variable-speed drive can control speed accurate within 0.1 per cent, it is obvious that this degree of accuracy is multiplied by the differential ratio. For example, a speed change of 0.24-rpm in the variable-speed transmission effects a change of only 0.06-rpm in the output of a 4 to 1 differential.

In the operation of a unit of this kind it is interesting to consider what happens at the instant of starting. In the first example (using a 3 to 1 differential) if the variable-speed transmission does not instantly develop torque equal to one-fourth of the load reaction, it will tend to be driven in reverse at a speed which, while the spider is held stationary by the load, will equal three times the ring gear speed—in this case, 1800 rpm. For this reason, the variable-speed unit in such an arrangement must have a starting torque proportional to the full starting resistance of the load, in this case, one-fourth of it. If the sun gear were prevented from reverse rotation by a one-way clutch held in the housing and the variable-speed unit had negligible starting torque, the differential would then momentarily act like a planetary with stationary sun gear. The output shaft would turn initially at 450 rpm and gradually build up as torque increased in the variable unit. These two possibilities are outlined merely to emphasize the advantage

of a variable-speed unit with full starting torque, since it is obviously necessary to interconnect the ring-gear and sun-gear drives so that they start simultaneously.

As mentioned previously, the variable drive with power bypass is especially suitable on applications requiring automatic speed control. This is because a transmission of reduced capacity, in addition to lowering the size and cost, naturally requires less power to alter its speed. In the cigarette machine, weight of the cigarette is measured continuously by its electrical capacitance, it having been found that this is the most accurate means of instantaneous weight measurement. Any variation from a predetermined standard of weight is translated through an electronic circuit to operate a pilot motor, either forward or reverse as required. This changes the speed of the variable drive to alter the rate of tobacco feed accordingly. In adjusting the transmission, the pilot motor circuit remains closed for short periods only, and time is allowed for cigarette rod of adjusted weight to be checked before further feed adjustment is made. Once started, the pilot motor turns only a few revolutions, and is then braked to insure the same number of turns each time. Since little power is required to adjust the transmission, a small lightweight gearmotor is adequate for this purpose. The low inertia of the pilot motor consequently enhances accuracy of speed regulation by minimizing acceleration and braking time.

Check Chart for Designers

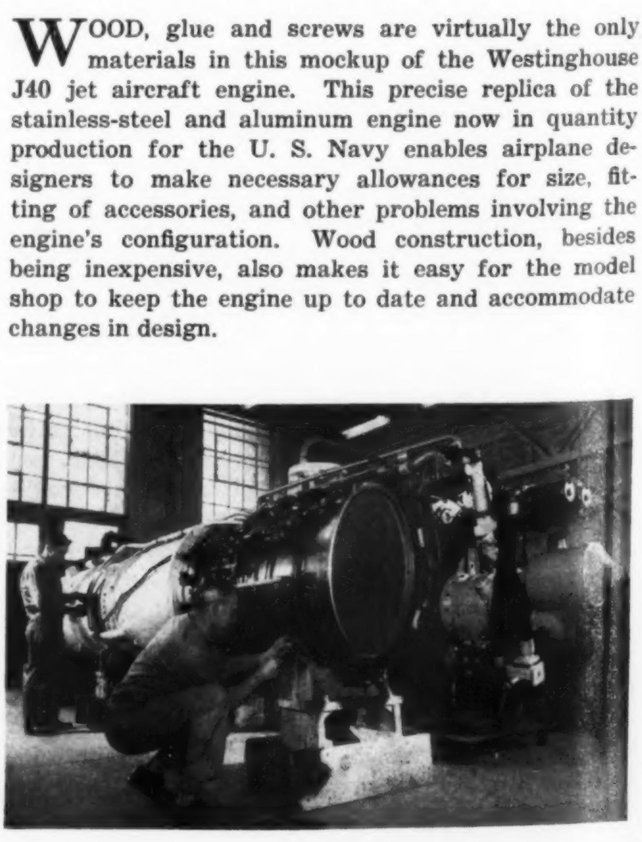
ALTHOUGH specifically prepared for designers of electronic equipment, the following check list illustrates a general procedure which all designers should follow. Originally developed by the Radio-Television Manufacturers Association and published in the form of a chart, it represents part of a program to increase the reliability of equipment through the proper selection and application of components. The 14 points mentioned for designers are:

1. **Determine circuit requirements** before selecting components, noting environmental and operational hazards
2. **Determine required component characteristics,** including all limiting factors established by standards or by the component's manufacturer
3. **Select components** that qualify under accepted standards, or with known capabilities wherever possible
4. **Specify parts** whose characteristics fulfill all circuit requirements, noting their limitations
5. **Check with approved supply source,** or with the manufacturer, for each specific part before final decision, if any doubt exists as to its performance capabilities with anticipated operating conditions
6. **Use derating factors** listed in standards or in military specifications for temperature effects, currents and voltage ratings
7. **Compensate for known limitations** in a particular component and in the end equipment design
8. **Apply safety factors** to compensate for any variable conditions which may be encountered
9. **Protect equipment** by fusing, metering, etc., to prevent damage by unexpected operating conditions
10. **Position components for temperature** so that total rise in component and circuit does not exceed maximum safe operating temperature. Heat radiated from surrounding parts should be considered
11. **Arrange components for accessibility** for testing and maintenance operations
12. **Provide ventilation,** adding a blower where necessary to keep components within safe ratings
13. **Add supplementary insulation** where necessary, especially when unusual operating hazards are found
14. **Check circuit functioning** with a random selection of tubes. Determine if shifts in tube characteristics or normal aging of other items are likely to affect operation seriously during desired equipment life.

The original chart, from which the above is abstracted, calls attention to the fact that reliability depends upon each component being used in the circuit under conditions established by its own capabilities. The chart was prepared at the suggestion, and with the assistance, of the directors of the Armed Services Electro Standards Agency.

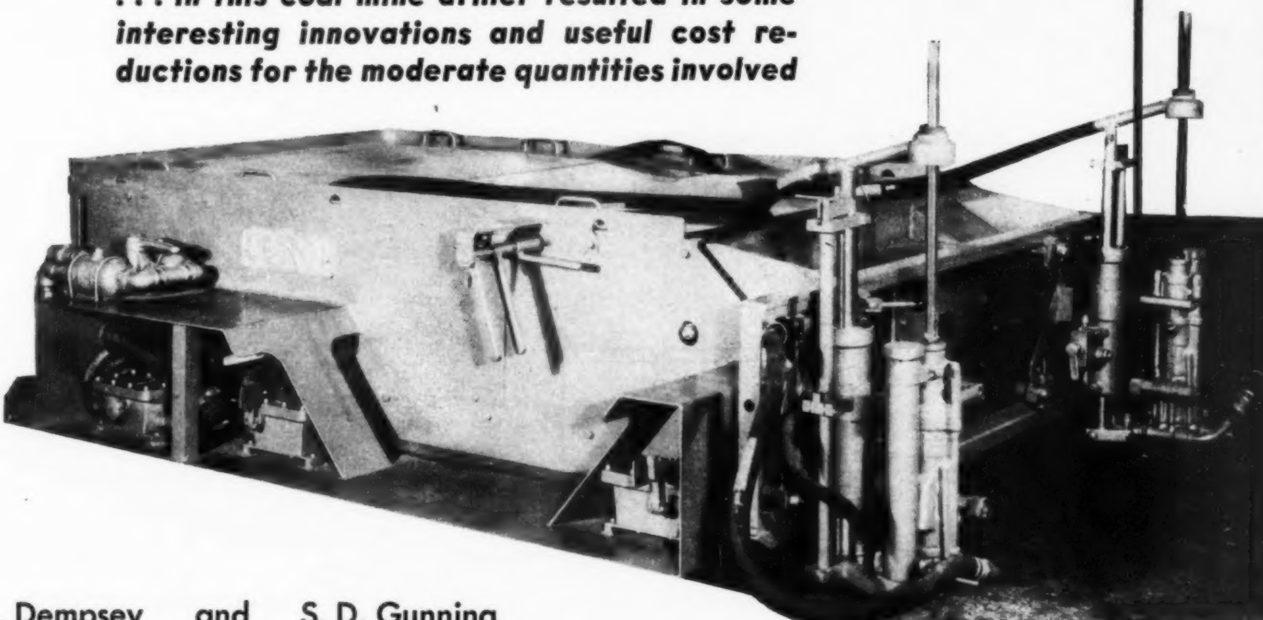
Wooden Jet Engine

WOOD, glue and screws are virtually the only materials in this mockup of the Westinghouse J40 jet aircraft engine. This precise replica of the stainless-steel and aluminum engine now in quantity production for the U. S. Navy enables airplane designers to make necessary allowances for size, fitting of accessories, and other problems involving the engine's configuration. Wood construction, besides being inexpensive, also makes it easy for the model shop to keep the engine up to date and accommodate changes in design.



Design for Welding

... in this coal mine driller resulted in some interesting innovations and useful cost reductions for the moderate quantities involved



By T. L. Dempsey and S. D. Gunning

Design Engineer, Lincoln Electric Co.

Chief Engineer, Cleveland Rock Drill Div., Le Roi Co.

Cleveland, Ohio

Fig. 1—Coal mine roof driller showing drills and welded cylinder arrangement for positioning units

RUGGED and maneuverable, the Le Roi Offset-Stoper Jumbo, *Fig.* 1, was especially designed to mechanize roof bolting operations in coal seams ranging from 38 to 58 inches in height. Two men in 15 minutes can drill, drive, and set eight roof bolts with the Jumbo. With hand-operated equipment, it would normally take three men as long as 45 minutes to do the same job.

Weighing 6000 pounds and measuring 7 feet wide by 12 feet long, the Jumbo is powered by a 5 hp 230-volt dc Reliance explosionproof motor mounted on the frame of a crawler type tractor. The motor output is delivered through a Mercury clutch and triple V-belt drive to a four-speed Clark transmission with speeds of 1, 2, and 3 mph forward and 1 in reverse.

The maneuverable Jumbo is steered by applying a hand operated brake to the right or left track, cutting the tractive effort up to 80 per cent. The brake handles, when pulled back together, latch to lock the tracks. Power is applied by two totally-enclosed switches operated by foot pedals from either of the opposed driver seats.

Health of the operator is protected by an efficient low-maintenance dust collector system. Both stopers, mounted on the front of the Jumbo, have cone shaped collector heads with narrow faces around the steels or drills. The narrow face keeps out large pieces, but smaller injurious dust particles are sucked into the collector system. Large dust particles, once in the system, settle in a gravity tank; smaller injurious dusts are filtered out by cloth type filters that are prevented from clogging by the low air velocity through the filter and the incidental vibrating action of the Jumbo.

Structural details of the Jumbo illustrate the versatility and economy of welded design. The frame is fabricated in two sections, the upper covering the top and sides, and the lower suspended between the tractor treads. Frame members are 2 x 2 x ¼-inch

Fig. 2 — Dust-collector head design for welding

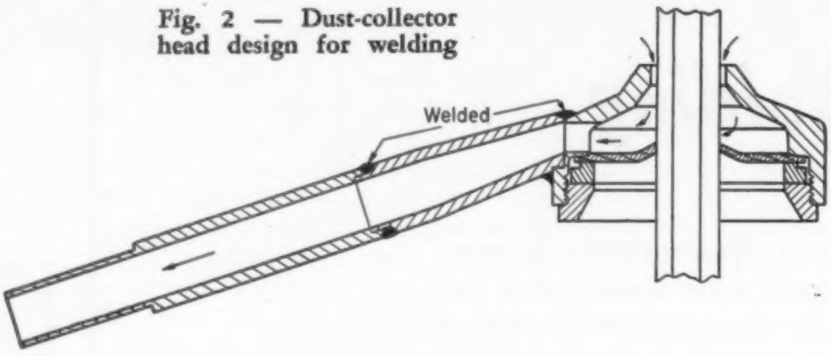


Fig. 3—Below—Exhauster chamber weldment in which progressive welded assembly is used

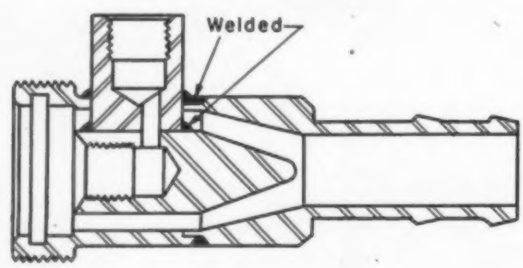
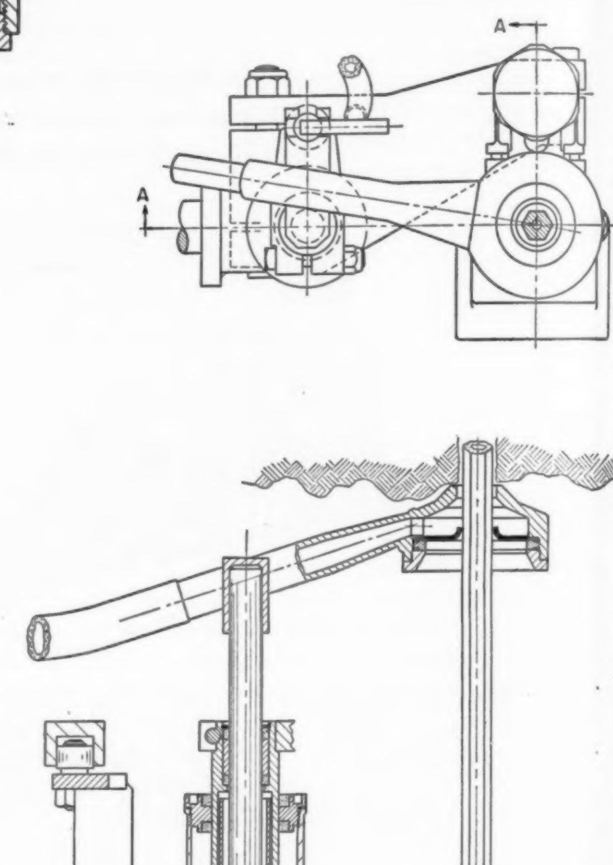


Fig. 4—Cross-sectional view of left cylinders and drill air motor arrangement



angle irons welded ¼-inch to 3-inch, 4-pound longitudinal channel stringers. Plate of ¼-inch thickness welded to the lower frame serves as a skid plate, preventing damage on uneven mine floors. Openings in the plate allow for the removal of accumulated debris.

The driver's control section consists of a welded assembly that is bolted to the right side of the Jumbo, *Fig.* 1. Welded from ¼-inch plate, the assembly carries the control handles, safety power switches, headlight switchbox and the main air coupling and valve. Two removable ¼-inch plates for carrying steels and other roof bolting gear are set into the top frame. The plates, provided with welded handles, can be lifted out whenever it is necessary to service the unit. A welded tray bolted to the front of the Jumbo carries smaller items. The rectangular dolly frame supporting the stopers is hinged at the front of the lower frame and bolted to the top frame. By removing the bolts and swinging the hinged stoper assembly down, the main power distribution panel can be readily serviced.

Dust Collector Head: The collecting chamber must be hard enough to resist abrasion and wear, yet strong enough to withstand shock and vibration. The inside surface of the chamber and the exhaust duct must be smooth to prevent the accumulation of dust particles. Rolled steel meets all the physical requirements as well as being inexpensive and readily available. The problem was one of mechanical design for the most economical use of this material. An analysis of the elements of the unit provided the answer: (1) A chamber surrounding the steel drill, open to

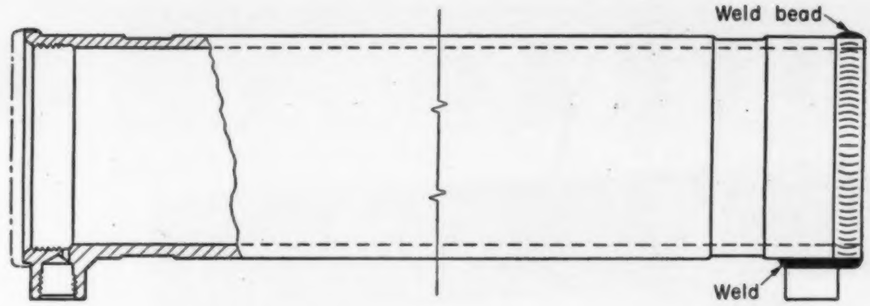


Fig. 5—Lift cylinder weldment showing rough welded tube, right, and finish machined part, left

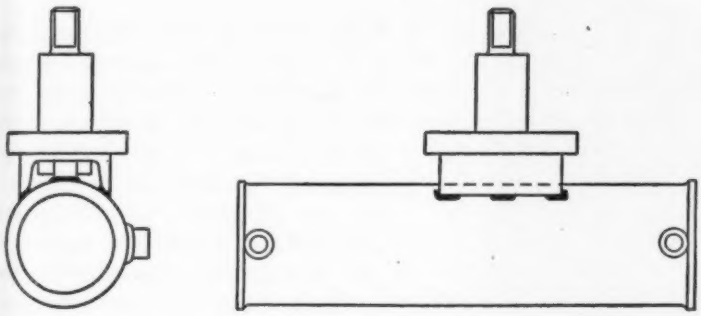


Fig. 6 — Lift cylinder trunnion bracket showing final welded design

provide a passage for dust on the top and sealed at the bottom; and (2) a transition piece connecting the chamber with a duct to which a rubber hose is connected.

The conical chamber, *Fig.* 2, is machined with a seat for a flexible diaphragm and retaining washer and is threaded for a nut. Three exhaust ports are drilled and a square step milled on one side of the chamber. The chamber and nut are carburized and hardened. The transition piece is tubular; flattened and milled at one end to cover the ports and seat on the side of the chamber. The duct is machined on one end to provide a lap joint with the transition piece and reduced in OD on the other end to accommodate a rubber hose. Welding provides a simple means of assembly. Hardness of the chamber is not impaired by the welding because of the localized heating of the arc weld.

Exhauster Chamber: The chief design requirement on this unit which powers the dust system is to introduce the center jet while maintaining a smooth-walled passage of uniform cross section for the main stream of air, *Fig.* 3. This is achieved by progressive welded assembly of machined components. The center cone and rectangular cone support are welded as a subassembly and inserted in a longitudinal slot in the main chamber. The chamber tip is added last and the assembly welded. A welding fixture gives good concentricity and allows little distortion of the weldment. The undercut chamber bores, the cone ports and chamber thread are machined after assembly.

Lift Cylinder: General arrangement of the drill mounting assembly is shown in *Fig.* 4. The lift cylinder of this unique unit provides two good examples of the ingenious use of welding techniques. The main requirements in this design were compactness and simplicity. The cylinder is double-acting, with a thin piston mounted with snap rings on a rod passing through and supported by a thin cap screwed into each end. The machine functions and operating conditions did not require a precision cylinder, and it is interesting to note that this cylinder met only these conditions but made possible maximum simplicity of design. The cylinder is made from 4-inch OD by 3/16-inch wall seamless-steel tubing. The cylinder bore requires no machining. An end flange is required to provide bearing and seating for the end cap and O-ring seal. This is achieved by forming a bead or flange of weld on each end. A composite view of the cylinder is shown in *Fig.* 5, the right hand side being the weldment and the left hand side, the machined cylinder. Ports are provided by welding bosses onto the outside of the cylinder. The threaded end bore, end cap seat, and ports are machined after welding.

The cylinder is carried by a single trunnion mounted on the side. Several methods were tried and the simple one shown in *Fig.* 6 proved to be the most effective. The trunnion and cylinder are joined by means of an intermediate member, a short piece of standard channel. The channel is secured to the cylinder with intermittent welds and supported by a filler piece welded under the web. By using proper welding materials and techniques, the distortion of the 3⅝-inch diameter bore never exceeds 0.010-inch. Thus it is unnecessary to machine the bore after this welding operation.

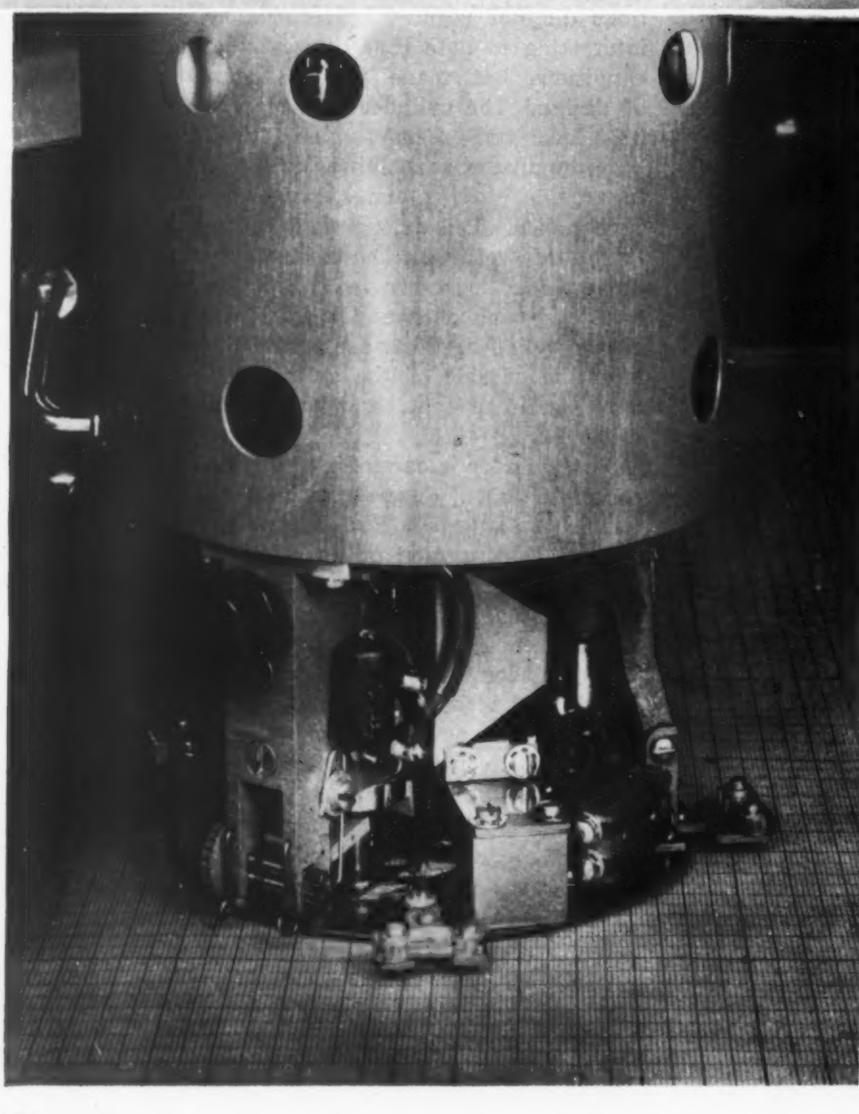
"Peacetime application of atomic energy as a power source for industry and the home may be nearer than generally supposed. Atomic power shows increased promise of being able to compete in price with coal, oil and gas in areas where these have high costs, and if this can be demonstrated successfully it is probable that its use in this respect will widen quickly."—DR. JOHN R. DUNNING, *dean, Columbia University*

CONT

Curve Plot

GRAPHICAL data can be plotted at the rate of 40 points per minute in chart areas ranging up to 26 x 55 inches by the automatic curve plotter shown at left. This is approximately ten times the speed of manual plotting, and the plotted data are not subject to human errors usually resulting from fatigue.

Heart of the machine is the reading and plotting head, left, below, which houses orthogonal photoelectric reading elements and a symbol printing mechanism. Bottom view of the head is shown below. The optical components are carried on a chromium-plated ring which rests lightly on the paper surface. Flat mounting springs permit the ring to accommodate itself to slight contour irregularities and yet retain positive axial location. Fixed reference pointers are provided on the ring to align the head with the co-ordinate axes, and to aid in positioning the printer at zero axis initially.

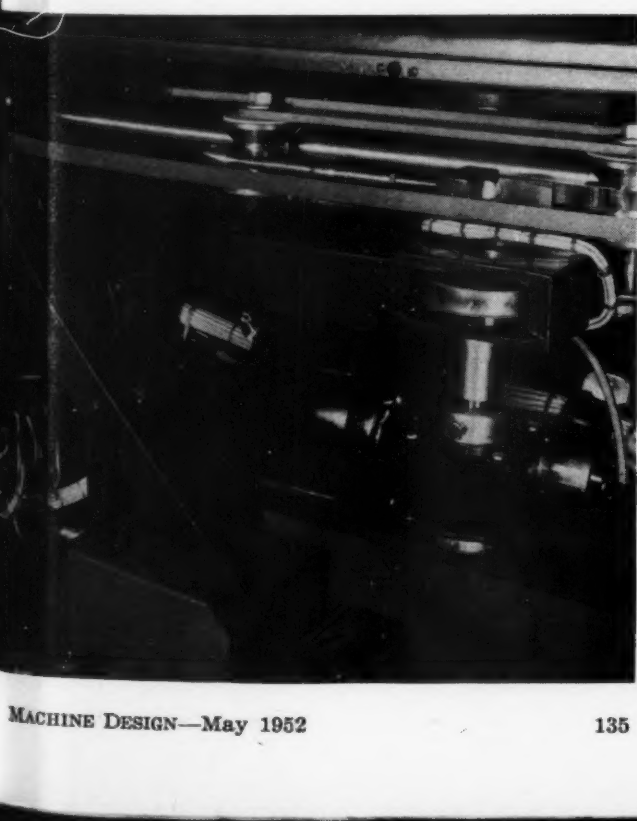


nts Grid Lines

Digital information is fed into an electronic accumulator circuit from IBM cards or other digital signal records causing the head to move in the direction of the points to be plotted. The head carriage in the arm and the arm carriage, below, are shifted by taut flat-steel belts powered by two Bodine constant-speed gearmotors.

As the head travels over the graph paper, the image of the grid lines is picked up and focused on a light-splitting system which excites the phototubes. Electrical impulses thus created are fed into the electronic counter circuit until the grid counts equal the previously stored data. At this point, traverse ceases and the printer solenoid is energized to print a symbol through carbon paper ribbon onto the chart. Sequential operation continues until the stored data for each point in a series have been plotted. Where a method of automatically feeding digital information into the circuit is not available or desirable, a manual keyboard can be installed as optional equipment in the upper right-hand desk drawer space.

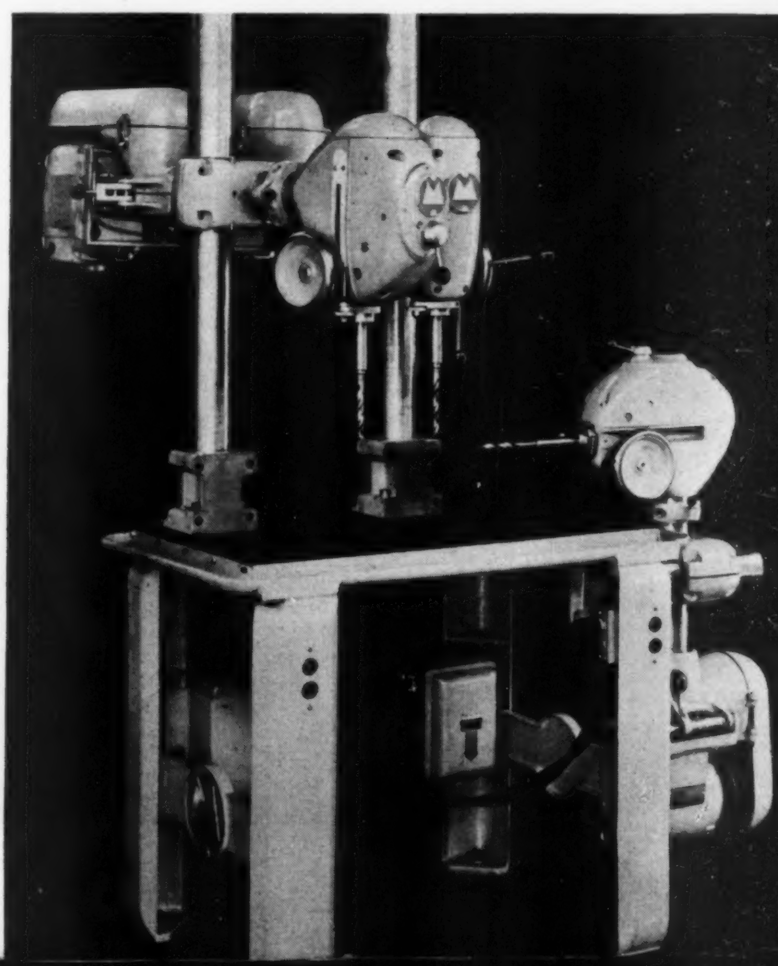
Because the plotting action depends on grid count versus input signal, paper stretch or nonlinearity does not result in errors. Plotting accuracy of the Teleplotter model 1B, made by Telecomputing Corp., is said to be plus or minus 0.5 mm, and the scanner is sensitive to co-ordinate paper having grid spacing as close as 20 lines to the centimeter.



Normal power service required is 230-v single-phase ac although provisions can be made to operate on 115-v ac. Power consumption of the basic machine, exclusive of input signal apparatus, is 3000 watts at nearly unity power factor. Electronic units are plugable to simplify servicing, and forced draft cooling for all control equipment is induced by blowers located near the floor.

Timing Belt Drives Drill Head

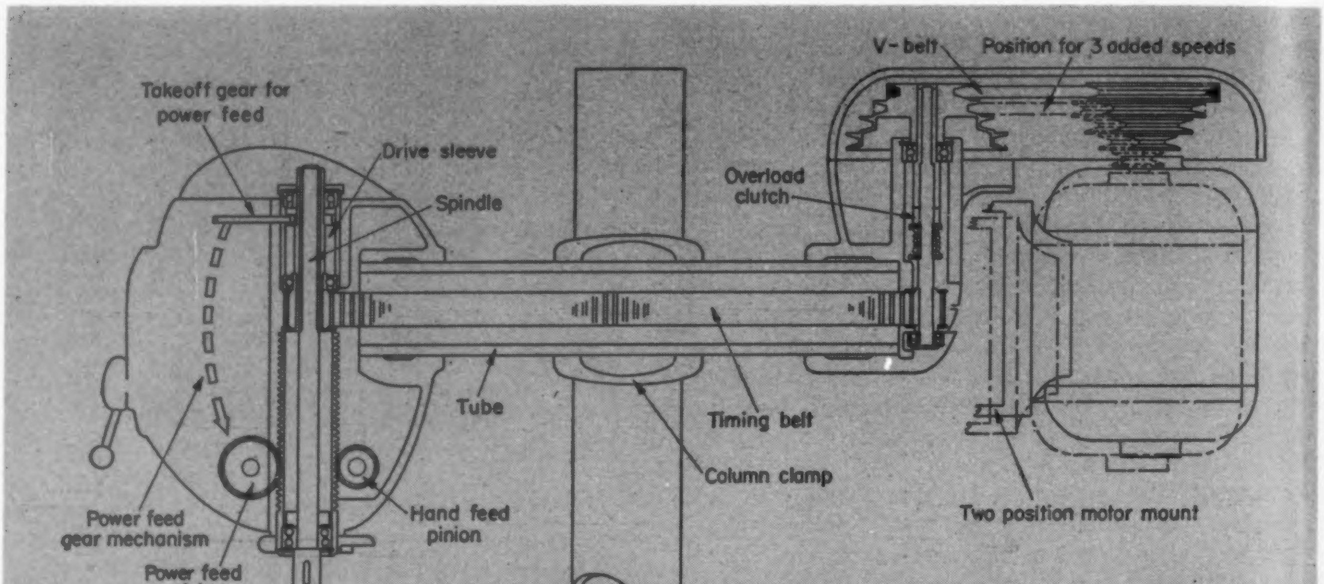
UNIVERSAL positioning of a new drill head, below, is made possible through a unique drive design utilizing a Gilmer timing belt inside the steel crosstube to transmit power to the drill spindle. Steel-reinforced, the molded belt is capable of operating with fixed

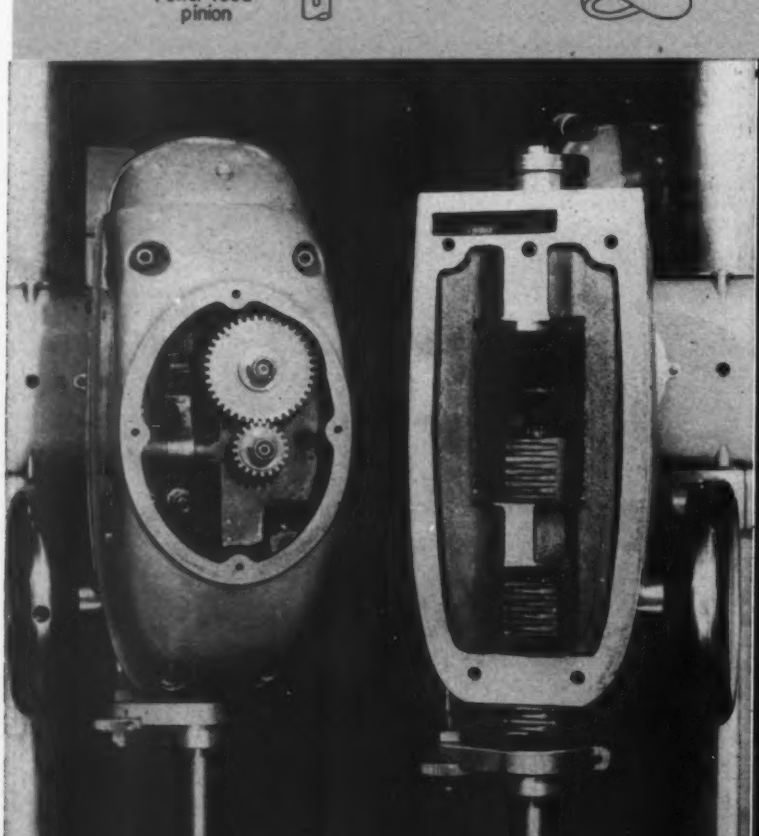


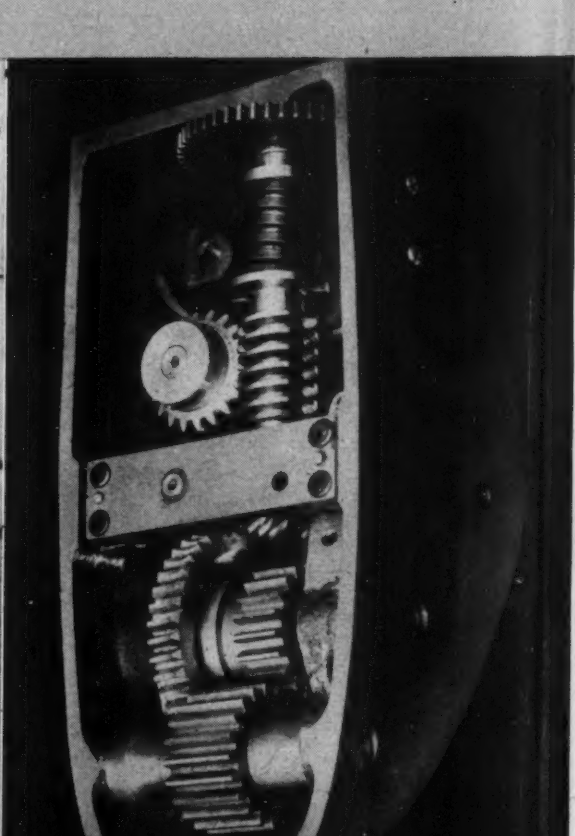
center-distance between gearlike pulleys. The flanged drive pulleys are sintered iron pressings that, although necessarily small in diameter, provide a 2 to 3 ratio between the jackshaft and spindle drive sleeve, diagram below.

An overload clutch is built into the jackshaft which is driven through a four-step V-belt drive from a 1-hp motor. The hinged motor plate has a lever-operated bayonet lock arrangement by which the motor can be shifted one V-groove space axially to provide a seven-speed drive. Quick release of V-belt tension to enable speed-change is accomplished by a toggle linkage having two different "over-center" positions. This allows for the normal variation in shaft center distance when using the same belt in either the four-step or the three-step range.

Prelubricated sealed ball bearings are used on both the jackshaft and the spindle drive sleeve. One end of the spindle is guided in the drive sleeve and driven by a close-fitting involute spline. A double-row ball bearing carries the other end of the spindle in a feed quill which has separate racks for the hand feed and for a power feed, below, that can be installed in place of a plain cover plate on the front of the head.







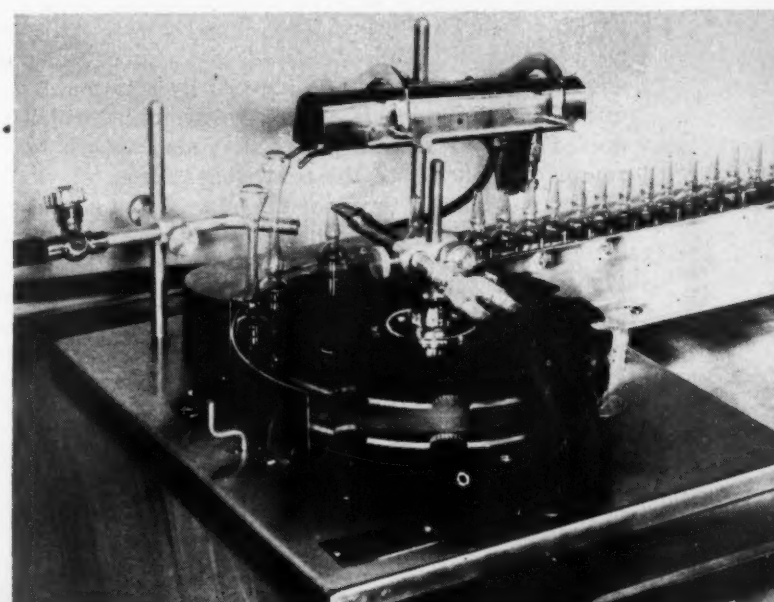
A helical Micarta pinion for driving the automatic power feed mechanism is part of the standard drive sleeve assembly. This pinion engages the input gear of the feed unit which consists of two worm gear reductions and a swing-mounted idler that meshes with the quill pinion to engage the feed. Solenoid control for the feed is also built into the housing, and an emergency disengaging lever is provided on the front cover plate.

Drilling depth is controlled by an adjustable stopnut which can be set relative to the housing as indicated by a scale on the left-hand side of the head. Maximum drillpoint pressure is also controllable through a screw adjustment inside the feed input shaft, but accessible outside the housing. This adjustment varies the initial thrust of a square-wire helical spring that positions the input worm endwise. When the depth stop contacts the housing—or should the feed pressure exceed the preset pressure for other reasons, such as poor drillpoint condition or hard material—resistance in the gear train will cause the input worm to move axially against the thust spring and trip the feed release lever.

Developed by Magna Engineering Corp, this versatile machine has a 5-inch feed stroke and will drill up to ¾-inch holes in steel; 1-inch holes in cast iron.

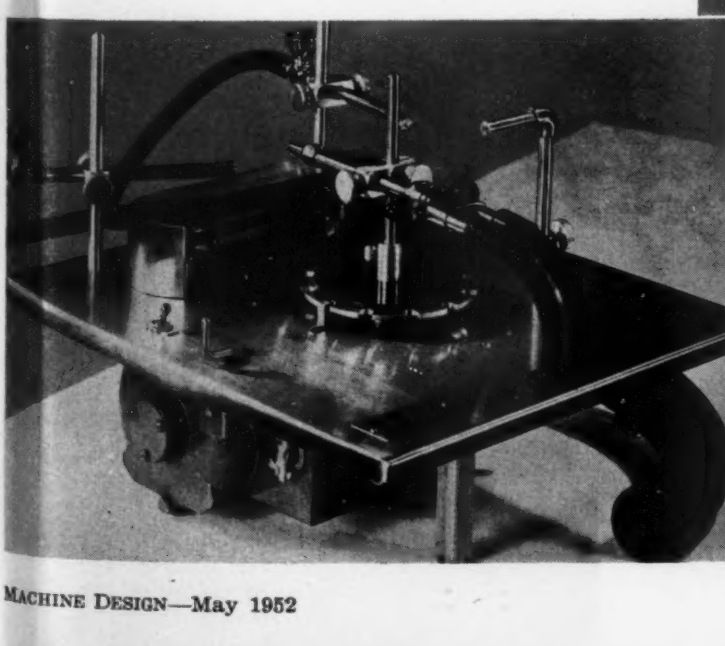
Friction Drive Indexes Sealer

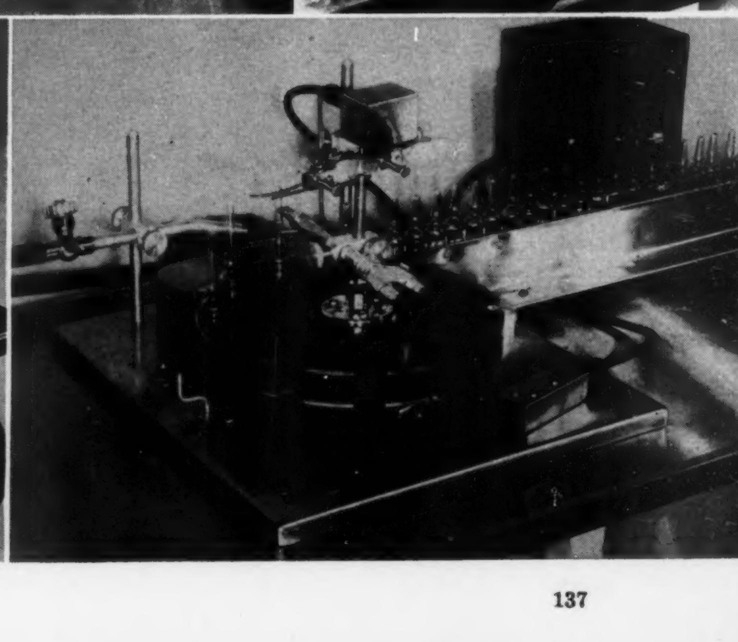
HIGH-SPEED uniform sealing of filled glass ampoules and tubes is accomplished through automatic tip-removal mechanisms designed into Kahlenburg rotary hermetic sealers. Shown at right is one of these machines arranged for sealing bell-topped ampoules.



Filled containers are loaded manually into semicircular cutouts in the outer edges of two Bakelite carrier disks keyed to a 12-station rotary indexing plate. The ampoules are rotated frictionally in the carrier through contact with the periphery of a single V-belt, below, which runs between a stud-mounted idler pulley and a driving pulley mounted on the output shaft of a 1/20-hp gearmotor. Pulling action of the belt also rotates the carrier from station to station when the index locking finger is released.

Cutouts in the bottom carrier disk are stepped counterclockwise ahead of those in the top disk to incline the axes of the amoules two-degrees off vertical. This





induces belt sideslip to hold the rotating ampoule firmly downward against the surface plate.

Each time the carrier indexes, the top of the ampoule approaching sealing station enters the open jaws of a weighted tilting slide and pulls it downward, locking the carrier. When heated to a plastic state by oxygas flame, the neck twists shut because of friction between the rotating bell top and the slide jaws. Controlled by dashpot to avoid premature parting, gradual upward pull of the tilting slide separates the neck at the twisted section and lifts the top from the ampoule. Further slide tilt releases the lock, permitting the carrier to index and discharge the sealed container into a magazine lined with resilient protective baffles.

For sealing straight-stemmed ampoules, the stems are grasped in spring-loaded tungsten wire jaws, lower right, previous page, while being heated and twisted to form the seal. Controlled by a Cramer electric timer, a solenoid is energized to lift the jaws and remove the tip. Simultaneously, another solenoid releases the index finger permitting the carrier to rotate. Enroute to the discharge magazine, the sealed ampoule contacts a cam shaped arm causing the jaws to swing away from the machine and release the tip into a scrap-chute.

Developed and built by Kahlenburg Laboratories, these machines are capable of handling containers up to 50-ml capacity, and can produce up to 3000 seals per hour. A trigger is provided at the loading station to enable manual release of the index finger during setup or semiautomatic operation.

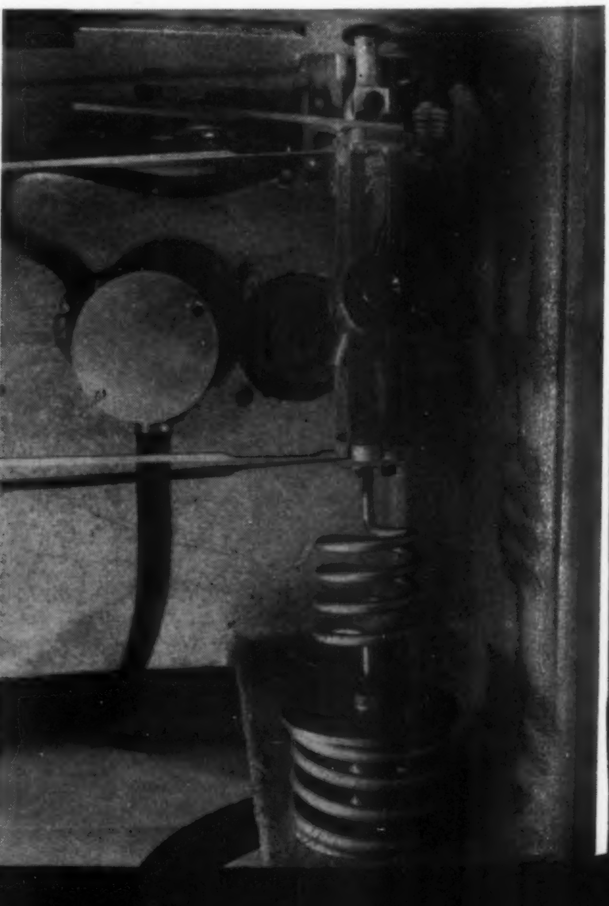
Fatigue Machine Tests Small Parts

SERVICE vibration conditions can be simulated on small parts with the table-model fatigue machine shown below. Vibration is induced by rotation of an unbalanced mass inside a cage, below, right, which is guided by four flexure plates that also absorb horizontal components of the centrifugal force.

Dynamic load in terms of pounds may be varied by screw adjustment of the mass with respect to its center of rotation. A scale plate with graduations representing increments of 0.125-lb enables quick setup for a specified test. Alternating force capacity ranges from zero to 25 lb at 1800 cycles per minute.

A 1/4-hp synchronous motor drives the mechanism through a lightweight shaft equipped with flexible couplings to permit a 1/2-inch maximum travel of the loading yoke. A tension-compression spring attached to the bottom of the cage provides inertia force compensation.

Static preload within the capacity of the machine may be applied either upward or downward by an adjustable compression spring accessory shown mounted below the inertia spring. The Baldwin-Sonntag SF-2 fatigue machine is equipped with an electromechanical counter to record cycle life of test specimens.



ALUMINIZED COATINGS

... for cast iron and steel offer effective low-cost heat and corrosion protection

By
M. G. Whitfield
and
V. Sheshunoff
Metallurgical Consultants
Garden City, N. Y.

Fig. 1 — Group of aluminized steel parts for use at elevated temperatures

ALTHOUGH considerable information is available on aluminizing of steel, relatively little is published on the subject of aluminized cast iron. Cast iron is an excellent engineering material for many uses but it is of limited value at elevated temperatures, or under certain corrosion conditions, unless it is alloyed with chromium and nickel or given a protective coating of aluminum.

With the existing shortages of chromium, nickel and other alloying elements, it seems advisable to consider the possibilities of aluminizing processes. This is particularly urgent in cases where the alloying elements are added primarily to confer the antiscaling properties on the base metal. In those cases where chromium, nickel and other metals are used to impart greater strength at elevated temperatures in addition to antiscaling properties, the amount of these elements can be reduced by bearing in mind the oxidation resistance afforded by aluminizing.

Processing: The aluminizing process, as discussed in this article, is one of the simplest available today and has been successfully used for a number of years, *Fig*. 1. This process is suitable not only for ferrous metals but also for a number of nonferrous metals as well. Minor modifications in processing are necessary for aluminizing copper and copper-base alloys. Both cast iron and steel are treated in an identical manner, depending of course on the end use of the part.

Aluminizing of cast iron or steel can be carried out by observing a few fundamental rules. The most important step in aluminizing, as in galvanizing or tinning, is to have surfaces as clean as possible. In the case of cast iron, practically any conventional method which will remove dirt and scale or oxides from the metal surface is satisfactory. Unlike hot-dip tinning, it is not necessary to remove the graphite present on the surface of cast iron by chemical means. Ordinary, commercial-grade aluminum has a great affinity for iron or steel and will alloy readily with it to form a continuous coating, *Fig*. 2.

Following cleaning, parts are immersed in a molten aluminum bath. Temperature of the bath is not critical—cast iron has been coated at temperatures from just above the melting point of aluminum on up. The time of immersion depends to a large extent on size and heat lag. A few minutes immersion time is usually sufficient to produce an adherent coating. Withdrawal from the bath should be done so as to permit good drainage of excess metal, unless the excess is needed for some specific design requirement.

Alloys: Besides commercially pure aluminum, various aluminum alloys can also be used, provided they have satisfactory corrosion and heat-resistant properties. Some alloys, particularly the aluminum-silicon type, have the advantage of greater fluidity, good brazing characteristics, and distinct tendency to form a thinner intermetallic bond between the base metal and aluminum coating.

Cost of Coatings: The cost of aluminizing is, in general, comparable to that of porcelain enameling. One pound of aluminum is sufficient to cover about ten to fifteen square feet of surface. Secondary or even a good grade of scrap aluminum can be used for processing.

Properties and Finish: Aluminized cast iron has the appearance of cast aluminum. The coating, averaging about 0.005-inch thick, is fused to the base metal with a formation of a complex intermetallic compound. The alloy bond is relatively thin, hard and brittle. However, without the bond the aluminum coating would give very little protection to the base metal, especially under oxidizing conditions at elevated temperatures. In certain applications, where the appearance is just as important as the performance, the aluminum surface can be finished by some of the methods common in solid aluminum finishing to give a range of finish from dull matte to bright polish.

Aluminum coatings are known for their resistance to heat oxidation and corrosion in general. Since the aluminum coating on cast iron is quite thick compared with other common coatings, there is plenty of aluminum to give the base metal ample protection. Actually, the corrosion resistance of parts treated in this way can be compared to solid aluminum, since the porosity of the coatings is practically nil.

Another interesting property of aluminum coatings is their ability to render the iron extremely heat resistant. In addition, the growth of cast iron due to gas penetration and absorption at elevated temperatures is practically eliminated. Comparative heat oxidation tests made with plain and aluminum-coated cast-iron rods at 1800 F showed virtually no increase in the size of the aluminized rod, whereas the plain cast iron rod showed a considerable increase in cross section. Aluminized cast iron can be heated to around 1200 F without losing any of its original color. However, prolonged exposure at higher temperatures will cause a certain amount of diffusion to take place —aluminum alloying with the base metal to form a rather complex alloy and the outer skin oxidizing to form a highly refractory aluminum oxide.

Among the noteworthy properties of iron-aluminum alloys is their high hardness, on the order of 50 Rockwell C or higher, and resistance to oxidation at elevated temperatures and attacks by a number of other media. It is known that even the 8 per cent aluminum-iron alloy is superior in heat resistance to the 80-20 nickel-chromium alloy.[1] Another interesting property of iron-aluminum alloys as well as aluminum coatings, is their ability to withstand the action of carburizing gases. For this reason, they have been used for many furnace applications.

One of the most unique properties of aluminized articles is their resistance to high temperatures in presence of sulphur-bearing gases. A few years ago, tests were conducted to determine the life of various materials, mostly nickel-chromium types, under the above conditions.[2] In every instance, the aluminized metals stood up exceptionally well. The results of these tests are tabulated in TABLE 1.

Another set of tests was made abroad with the results shown in TABLE 2, representing the losses of several materials after 50 hours of heating in a stream of hydrogen sulphide (20 liters per hour) without intermediate cooling.[3]

Table 1—High-Temperature Resistance of Aluminized Steel

(In presence of sulphur-bearing gases)

Steel Samples	Temp. (F)	Time (hr)	Weight-Change* (%)
Untreated 18-8 Cr-Ni	1350	24	−17.0
Untreated 25-20 Cr-Ni	1350	4	− 8.3
Untreated 27% Cr steel	1350	24	− 8.4
Aluminized 18-8 Cr-Ni	1350	192	0.1
Aluminized plain steel	1350	192	0.1
Aluminized 18-8 Cr-Ni	1700	48	0.0
Aluminized plain steel	1700	48	0.3

* After corrosion scale was tapped off.

Table 2—Losses of Materials Heated in Hydrogen Sulphide

(grams per hour per square meter)

Material	Temperature 930F	1110F	1290F
3% Cr, 2.5% Si steel	13	73	....
6% Cr, 2.5% Si steel	11	63	....
18% Cr, 2.5% Si steel	4.2	11	....
18-8, Cr-Ni steel	6.5	18	....
Plain steel	19	..	....
Aluminized plain steel	..	0.02	0.20

Applications: Although the use of aluminized cast iron is rather limited at present, there are numerous potential applications where either improved resistance to heat oxidation or corrosion in general are desirable. Also, a decorative finish of the aluminum coating may be utilized to give a distinct sales advantage; in the polished condition it resembles chromium plate.

In conclusion, it is important to note that, in addition to the use of aluminized cast iron for heat, oxidation and corrosion-resistance, there is still another potentially large field covering composite castings of aluminum and iron.[4] Some of the more interesting applications in this field at the present time are bimetallic brake drums and bearings with an aluminum alloy lining.

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1. N. A. Ziegler, "Resistance of Iron-Aluminum Alloys to Oxidation at High Temperatures," *Transactions*, AIME 100, 267, 1932.
2. Test Data—Socony Vacuum Oil Co.
3. G. Kremer and K. E. Volk, *Stahl und Eisen*, Vol. 66-67, 1947.
4. M. G. Whitfield and V. Sheshunoff, "Bonding Aluminum to Ferrous Metals," *Iron Age*, Vol. 162, No. 1, pages 88-93, 1948.

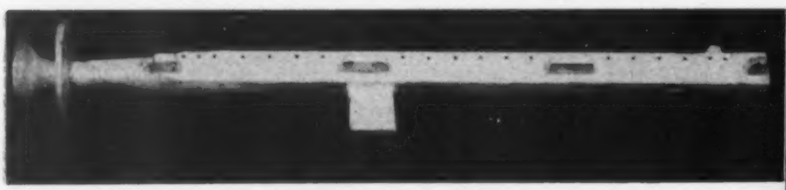
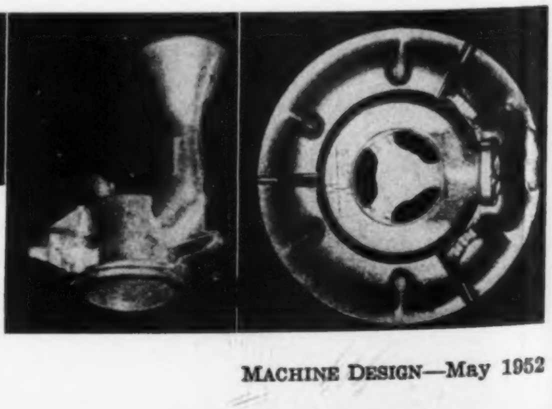



Fig. 2—Various cast-iron burner parts aluminized for oxidation, heat and corrosion resistance

Noncircular Cams and Gears

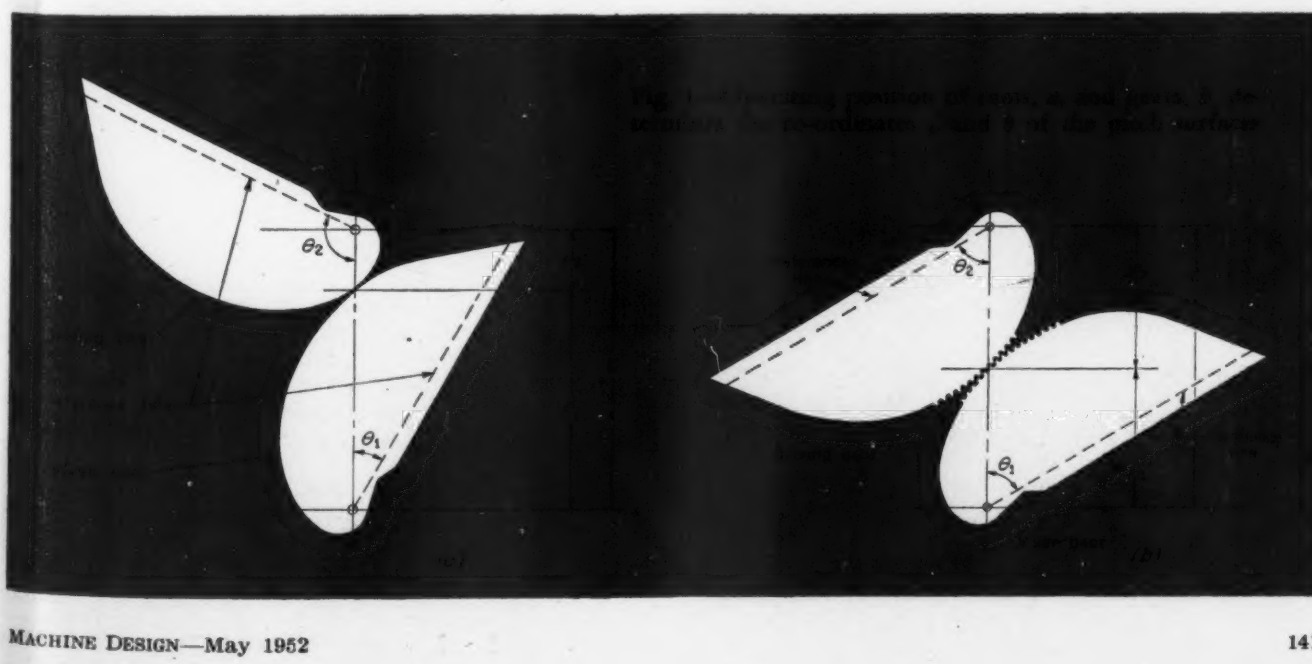
. . . for transmitting motion at a continuously varying velocity ratio

By A. E. Lockenvitz, J. B. Oliphint, W. C. Wilde and James M. Young
The University of Texas
Austin, Texas

Compact and efficient, noncircular cams or gears are used to impart an intentionally varying velocity ratio to two parallel shafts. From knowledge of the desired motion relationship, equations defining the pitch lines of the mating pair are established by a rational procedure. Computed from the equations, co-ordinates specify the profiles to be produced. Dependent on quantity and quality requirements, standard production methods and equipment can be utilized in the manufacture of the parts.

As MACHINE components, noncircular surfaces provide a simple and efficient means for linking input and output shafts where the required motion relationship, expressed mathematically, is a nonlinear function. This type of transmission produces a continuously varying velocity ratio between the shafts, usually within a limited angular travel. Noncircular cams and gears have been successfully used in control and computing equipment, measuring devices, printing presses, shapers, and slide-valve mechanisms.

Noncircular mating cams are cam pairs operating with true rolling contact in the manner of gears with theoretical pitch lines as contact surfaces but with no teeth, *Fig. 1a*. Because action of the cams is restricted to pure rolling of their pitch surfaces, the point of contact is always on the line joining the centers of rotation. Also, since these cams are the connecting bodies between two shafts, the distance between the



centers of rotation always remains constant.

To insure pure rolling of the cams (no slippage), radii from centers of rotation to successive points on the pitch surfaces must be continually increasing for one cam, continually decreasing for the other. This limitation requires that the function shall not pass through maximum or minimum points within the range to be considered. It must be monotonic.

Noncircular gears are analogous to noncircular cams. That is, the pitch lines of gears are the same as the pitch or working lines of cams. However, since teeth maintain positive engagement, application of noncircular gears is not restricted to monotonic functions.

Therefore, type of function to be mechanized is, in part, a criterion for selection of cams or of gears. If the function is not monotonic, gears must be used. If the function is monotonic, cams generally are preferred, providing torque to be transmitted is not great. Gears usually are less favored for monotonic functions because of difficulties in cutting teeth and in achieving precision.

Basic equations needed for the specification of pitch lines of noncircular cams and gears are easily developed. They may be applied in design and production by relatively simple techniques.

Noncircular Cams: In *Fig.* 1*a*, input and output cams are shown in operating position. Since the two cams are always in contact, the angular position of the driven shaft, θ_1, may be expressed as a function of the angular position of the driving shaft, θ_2:

$$\theta_1 = f(\theta_2) \quad \dots\dots (1)$$

In pure rolling contact the incremental arc lengths traversed are equal. If arc length is expressed as

$$ds = [(\rho d\theta)^2 + (d\rho)^2]^{1/2}$$

it is apparent that

$$[(\rho_1 d\theta_1)^2 + (d\rho_1)^2]^{1/2} = [(\rho_2 d\theta_2)^2 + (d\rho_2)^2]^{1/2} \quad \dots\dots (2)$$

Fig. 2—Angular spacing of flats produced by the cutter dictates magnitude of cam profile errors

Since the point of contact is on the line of centers,

$$\rho_1 + \rho_2 = C \quad \dots\dots (3)$$

from which

$$d\rho_1 = -d\rho_2 \quad \dots\dots (4)$$

Equations 1, 2, 3 and 4 are basic for the design of any noncircular cam. They can be used to obtain suitable relationships for defining the pitch profiles. Substituting Equations 3 and 4 into Equation 2 gives

$$\rho_1 d\theta_1 = \rho_2 d\theta_2 = (C - \rho_1)\, d\theta_2 \quad \dots\dots (5)$$

By differentiation of Equation 1,

$$d\theta_1 = f'\,(\theta_2)\, d\theta_2 \quad \dots\dots (6)$$

where f' denotes the first derivative. Substituting Equation 6 into Equation 5 gives

$$\rho_1 f'\,(\theta_2)\, d\theta_2 = (C - \rho_1)\, d\theta_2 \quad \dots\dots (7)$$

or

$$\rho_1 = \frac{C}{1 + f'\,(\theta_2)} \quad \dots\dots (8)$$

Substituting Equation 8 in Equation 3 yields

$$\rho_2 = \frac{Cf'(\theta_2)}{1 + f'(\theta_2)} \quad \dots\dots (9)$$

Equations 8 and 9 are design equations for the pitch profiles of mating cams in terms of radius ρ and angle θ.

EXAMPLE 1: Establish the equations for profiles of cams which rotate according to a reciprocal function. That is, the angular positions of the cams are to be related as

$$\theta_1 = -\frac{K}{\theta_2} = f(\theta_2) \quad \dots\dots (10)$$

where K is a constant of proportionality and may, within certain limits, be chosen arbitrarily.

By differentiation,

$$f'(\theta_2) = \frac{K}{\theta_2{}^2} \quad \dots\dots (11)$$

Combining Equations 10 and 11 with Equations 8 and 9 gives

$$\rho_1 = \frac{CK}{K + \theta_1{}^2} \quad \dots\dots (12)$$

$$\rho_2 = \frac{CK}{K + \theta_2{}^2} \quad \dots\dots (13)$$

For this particular case both cams have the same pitch profile, are images of one another, and can be cut together.

Not all functions produce such simple results, of course. Another form often encountered in the transformation of motion is the exponential.

EXAMPLE 2: Find the profile equations for the following desired exponential relationship in which A and K are constants of the system:

$$\theta_1 = Ae^{n} = f(\theta_2) \quad \dots\dots (14)$$

where $n = \theta_2/K$. Again by differentiation,

$$f'(\theta_2) = Ae^n \frac{dn}{d\theta_2} = \frac{A}{K} e^n \quad (15)$$

Then by use of Equations 8 and 9

$$\rho_1 = \frac{CK}{K + \theta_1} \quad (16)$$

$$\rho_2 = \frac{CA}{Ke^{-n} + A} \quad (17)$$

After the constants appropriate to an actual design are introduced, equations for the two profiles can be easily evaluated and tables constructed of ρ versus θ.

Two methods for cutting these cams are continuous cutting and increment cutting. The first of these methods, while excellent for quantity production, is hardly worthwhile for a single pair of cams, or even several pairs, because of the necessary outlay of time and equipment.

Increment cutting consists of milling or grinding a series of flats, each tangent to the pitch surface. The angular separation of these flats governs the accuracy obtained. Accuracy improves with smaller increments of θ, that is, with more cuts, *Fig.* 2. If increment cutting is to be used, rectangular co-ordinates for machine settings are more helpful than the profile polar co-ordinates alone.

The angular position of the cam in *Fig.* 3 at a certain cut is $\theta + \alpha$ and the cam should be rotated to this angular position as measured from a known zero position, perpendicular to the mill table. Since the cut is to be tangent to the pitch surface, it is necessary to find the slope of the surface at the point of tangency. From *Fig.* 4, the tangent of the angle between the normal to the surface and the radial line to the point of tangency may be defined as

$$\tan \alpha = \lim_{\Delta\theta \to 0} \frac{1}{\rho} \frac{\Delta\rho}{\Delta\theta} = \frac{1}{\rho} \frac{d\rho}{d\theta}$$

Although development of this equation from *Fig.* 4 is simplified, the same result can be obtained by fully rigorous methods.

The bottom of the cutter is set at a distance $H = \rho \cos \alpha$ above the center of rotation of the cam, and the cut is made parallel to the table. The angular spacing between cuts varies with the rate of change of the slope of the pitch surface with respect to a radial line to the tangent point.

Factors entering into the final accuracy of the system can be demonstrated by analysis of the special case of reciprocal cams. Differentiating Equation 12 or 13 and dropping subscripts give

$$d\rho = -\frac{2\,CK\theta}{(K + \theta^2)^2}\, d\theta$$

This equation gives the radial error due to inaccuracies in setting θ, and it also gives in effect the error of θ due to inaccuracies in setting ρ in the cutting operation. That is, inserting a numerical value of angular error $d\theta$ yields a numerical evaluation of the radial error, $d\rho$. Expressed proportionally,

$$\frac{d\rho}{\rho} = -\frac{2\theta d\theta}{K + \theta^2}$$

In general, differentiation of Equations 8 and 9 with the evaluation of $f'(\theta_2)$ from $\theta_1 = f(\theta_2)$ leads to expressions for evaluating errors in output arising from the cutting operation.

Noncircular Gears: Design of the pitch curves of noncircular gears, *Fig.* 1*b*, is the same as for noncircular cam surfaces. Equations 1 through 9 define the curves. Also, from the general equations of arc length

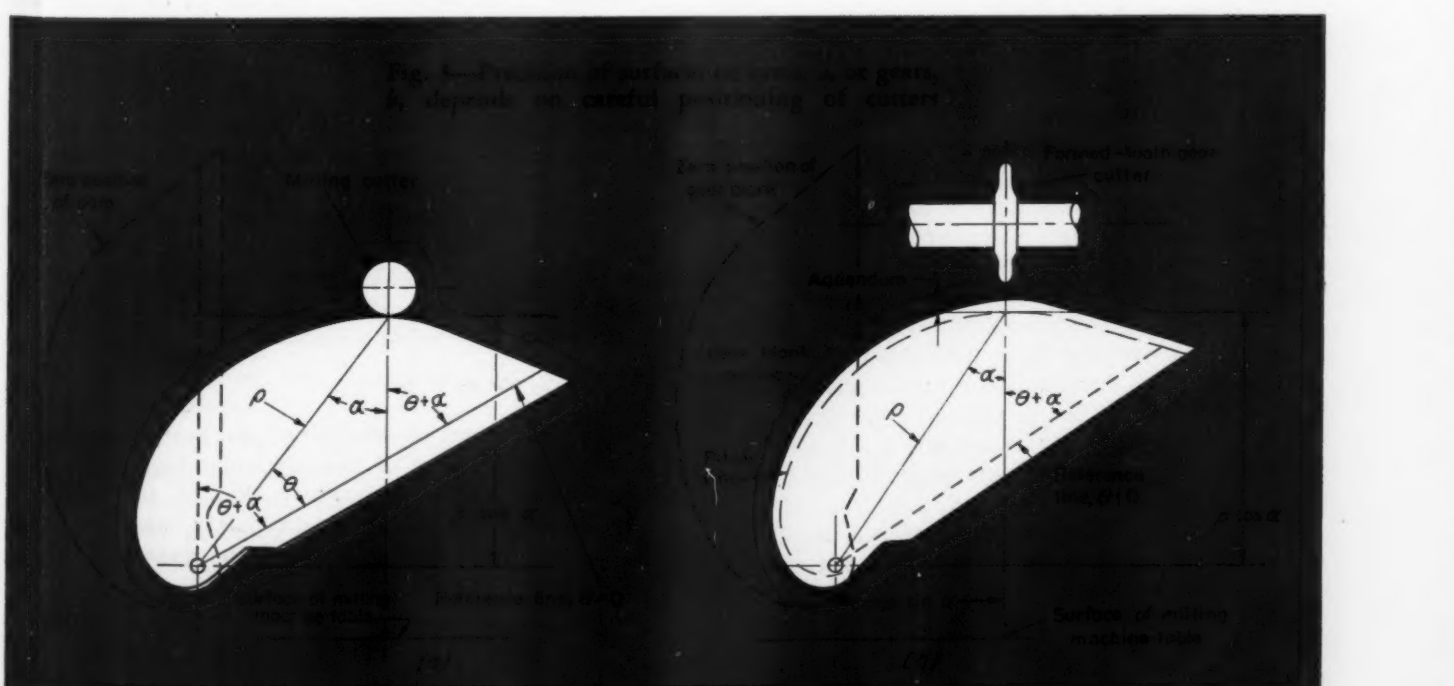


Fig. 3—Precision of surfaces on cams, a, or gears, b, depends on careful positioning of cutters

$$s_2 = \int_{\theta_a}^{\theta_b} \left[(\rho_2)^2 + \left(\frac{d\rho_2}{d\theta_2} \right)^2 \right]^{1/2} d\theta_2 \qquad (18)$$

where θ_a and θ_b define the limits of the usable portion of arc length s on the driving gear. By differentiation of Equation 9.

$$\frac{d\rho_2}{d\theta_2} = \frac{Cf''(\theta_2)}{[1 + f'(\theta_2)]^2} \qquad (19)$$

Substituting Equations 9 and 19 in Equation 18 gives

$$s_2 = \int_{\theta_a}^{\theta_b} \left\{ \left[\frac{Cf'(\theta_2)}{1 + f'(\theta_2)} \right]^2 + \left[\frac{Cf''(\theta_2)}{[1 + f'(\theta_2)]^2} \right]^2 \right\}^{1/2} d\theta_2 \qquad (20)$$

Equations 8, 9, and 20 are the design equations for noncircular gears.

The method of producing noncircular gears is dependent on quantity and quality requirements. In one method a fixture moves the work in a desired path while a circular, reciprocating cutter generates teeth on the work. This method is not recommended for high-precision gears. Another generating method uses precise function generators to control the motions of the work with respect to the cutter. This scheme can use either a reciprocating cutter or a hob.

Using a master cam to control the position of the work gives good results if the cam is precise. Hobbing grinders could be employed to great advantage in quantity production of such gears. However, the production of the master cam might be quite expensive if great accuracy is required.

Although the methods just mentioned are feasible, and some are highly accurate, they are not economically practical for small quantities of noncircular gears unless extreme accuracies are demanded. There is, however, the alternative of cutting noncircular gears with formed-tooth cutters. This involves calculating polar and rectangular coordinates for machine settings and using an indexing head or fixture and a series of milling cutters. The particular cutter to be used depends upon the pitch radius of the cut. This technique is slower and somewhat less accurate than the continuous generating methods. However, it is less expensive and fair results may be obtained if precision measurements for machine settings are made. A theoretical error is caused in this production technique by the change in curvature of the teeth as the pitch radius changes, but a small amount of lapping can reduce this error of conjugate gear tooth action. This error is further minimized by use of fine pitches.

In cutting noncircular gears with formed-tooth cutters, cuts must be made at whole increments of the circular pitch of the teeth along and always perpendicular to the noncircular gear blank surface. Therefore, if the first cut is to be made at a particular position, say θ_b, it is possible to calculate the total arc length from some initial reference line, say $\theta_a = 0$. Since the circular pitch, p, is known, consecutive whole increments of the circular pitch can be subtracted from the total arc length. By substitution of these known arc lengths in Equation 20, corresponding values of θ_2 can be calculated. With the aid of Equation 9, the corresponding value of ρ_2 can be calculated for each value of θ_2. This procedure for determining the positions of every cut is absolutely necessary because of the irregular spacing of the teeth with respect to θ_2.

Since the cut is to be perpendicular to the noncircular gear blank surface, tan α must be determined as for noncircular cams and the slope of the surface found.

As shown in *Fig. 3b*, ρ_2 is the length of a radial line from the center of rotation to the pitch line of the gear blank.

The gear blank may be prepared in the same manner used for making a cam of this type. The vertical distance from the center of rotation of the gear blank to the outline of the blank is

$$V = \rho_2 \cos \alpha_2 + a \qquad (21)$$

where a is the addendum of the gear teeth to be cut.

The angular position of the gear blank at a certain cut is $\theta_2 + \alpha_2$, *Fig. 3b*. The gear blank should be rotated to this angular position as measured from a known zero position perpendicular to the mill table.

With the gear blank rotated to a particular angular position for a cut, the bottom of the formed-tooth cutter should be set at a distance

$$Y = \rho_2 \cos \alpha_2 - b \qquad (22)$$

above the center of rotation of the gear blank, where b is the dedendum of the particular teeth to be cut. From the geometry shown in *Fig. 3b*, the center of rotation of the formed-tooth cutter must be offset from the center of rotation of the gear blank by a distance

$$X = \rho_2 \sin \alpha_2 \qquad (23)$$

Determination of the gear profiles is dependent on

the evaluation of Equation 20. Expansion of this equation into a series form may aid the solution.

EXAMPLE 3: Consider a pair of reciprocal gears for which Equation 10 of Example 1 defines the functional relationship. Then, pitch line profiles of the gears are defined by Equations 12 and 13.

Equation 11 is the first derivative of the function; the second derivative is

$$\frac{d^2\theta_1}{d\theta_2^2} = f''(\theta_2) = -\frac{2K}{\theta_2^3} \qquad (24)$$

Combining Equations 11, 20 and 24 gives

$$s_2 = CK\int_{\theta_a}^{\theta_b}\left[\frac{(K+\theta_2^2)^2 + 4\theta_2^2}{(K+\theta_2^2)^4}\right]^{1/2} d\theta_2 \qquad (25)$$

To simplify the procedure, let

$$\theta_2 = K^{1/2}\tan\phi_2 \qquad (26)$$

By differentiation

$$d\theta_2 = K^{1/2}\sec^2\phi_2\, d\phi_2 \qquad (27)$$

From Equation 26

$$\phi_2 = \tan^{-1}\left(\frac{\theta_2}{K^{1/2}}\right)$$

Then

$$\phi_a = \tan^{-1}\left(\frac{\theta_a}{K^{1/2}}\right) \qquad (28)$$

$$\phi_b = \tan^{-1}\left(\frac{\theta_b}{K^{1/2}}\right) \qquad (29)$$

Equations 28 and 29 give the new values of the limits for the evaluation of Equation 25. Combining Equations 25 to 29 and simplifying give

$$s_2 = C\int_{\phi_a}^{\phi_b}(K + 1 - \cos^2 2\,\phi_2)^{1/2}\, d\phi_2 \qquad (30)$$

Equation 30 cannot be evaluated by ordinary means of integration. Upon proper application of the binomial theorem to the integrand,

$$s_2 = (K+1)^{1/2}\, C\left[\int_{\phi_a}^{\phi_b} d\phi_2 - \frac{1}{2(K+1)}\int_{\phi_a}^{\phi_b}(\cos^2 2\phi_2)\, d\phi_2 - \frac{1}{8(K+1)^2}\int_{\phi_a}^{\phi_b}(\cos^4 2\phi_2)\, d\phi_2 - \frac{1}{16(K+1)^3}\int_{\phi_a}^{\phi_b}(\cos^6 2\phi_2)\, d\phi_2 \ldots\right] \qquad (31)$$

This series, of course, can be continued until required accuracy is reached.

One tooth space must be arbitrarily located with respect to the reference line $\theta = 0$. The arc length of the pitch line from the reference line $\theta = 0$ to the center of the particular tooth space, s_2, may then be calculated, as with Equation 31, letting $\theta_a = 0$ and θ_b the angular position of the center of the particular tooth space. Values of the limits, ϕ_a and ϕ_b, are obtained from Equations 28 and 29.

The angular position of an adjacent tooth space must then be determined. For this particular cut the value of s_{2b} may be found by adding or subtracting one circular pitch from the first value of s_2. Thus, s_{2b} is known as well as the lower limit of integration which is zero, but the upper limit is unknown. It is recommended that, with the aid of Equation 13, the pitch line of the gear be plotted several times actual size and the centers of the first and second tooth spaces be located. Angular position of the center of the second tooth space must be measured with respect to the reference line $\theta = 0$. With this trial value of θ_b, ϕ_b may be determined and the working relationship, such as Equation 31, may be evaluated. Approximations of the true value of s_{2b} can be obtained in four trials, or less, within 0.0001-inch where s_{2b} is the arc length associated with the second tooth space. This procedure should be repeated for all other tooth spaces.

Teeth on the mating gear must be offset from the positions found for the first gear by one-half the circular pitch. The same calculation and layout procedures may be used to locate the teeth.

Concrete Jigsaw Puzzle

THE concrete jigsaw puzzle shown is actually the foundation for a 42-foot vertical boring mill, one of the largest known removable-rail type mills ever built. Constructed at the General Electric plant in Schenectady, the foundation has walls almost two feet thick. It has an overall size of 37 by 59 feet, sinks 10 feet into the ground, and weighs 1134 tons.

The completed mill, constructed by the Consolidated Machine Tool Corp., will have a heavy table measuring 20 feet in diameter, and a removable cross-rail weighing 70 tons. Powered by a 100-hp dc motor, the mill will be used to machine hydrogenerator stator frames and upper-bearing bracket assemblies.

Some 100 tons of steel, including 18 tons of reinforcing steel, 10 tons of stud material, and 70 tons of piling, went into the foundation. Nearly 700 cubic yards of dirt were removed.

SIMPLIFIED

How new mechanisms and materials were utilized to meet buyer demands for ease of operation, light weight, less maintenance

By L. T. Askren
Project Engineer
Eastman Kodak Co.
Rochester, N. Y.

ONE of the most persistent demands among buyers of 16-mm sound-on-film projection equipment has been for lighter weight projectors which can be handled more easily by operating personnel—for example, by a 105-pound school teacher. Other requirements stress simplicity of operation, quietness and durability. These goals represent a real challenge to the designer of portable projectors because it is important that they be reached by methods that maintain or even improve the quality of the sound and picture. In designing the Kodascope Pageant Sound Projector, effective steps have been taken along these lines.

Original Specifications: When the specifications for this projector were first outlined, the following general objectives were listed as being the most essential in satisfying customer demands:

1. The machine should project a picture that is steady, brilliant and sharp. It should reproduce good sound film with unquestionable intelligibility and naturalness. Its mechanism should be quiet and unobtrusive in operation
2. It should be light and easily portable, yet sturdy, foolproof, easy to thread and operate, and easy on film
3. It should be durable despite operation by nontechnical personnel—often without lubrication, adjustment or even maintenance over a long period of time—yet servicing should be simple.
4. Finally, the complete sound projector should be reasonable in price.

...DESIGN FOR A FILM PROJECTOR

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Other Objectives: As planning progressed it became apparent that an entirely new approach to the problem would be necessary. At the outset, therefore, it was decided that existing parts and assemblies would be used only if they had exhibited excellent performance in previous adaptations and could not be improved without excessive increase in cost.

For example, it was found necessary to discard the lumiere cam, with all its kinematic beauty but inherent shortcomings, in order to reduce noise, attain long life without lubrication, avoid unsteadiness in the picture, and insure reasonable manufacturing tolerances. Also, it was considered desirable to investigate new materials, such as nylon, and new applications of ball and oilless bearings. Better and less expensive ways of stabilizing the sound system were needed to replace traditional, complicated methods.

The manner in which these objectives were achieved in the Pageant can best be evaluated if the machine is divided into its principal elements, and the approach to each is considered.

Picture Head: The projection or picture head consists of the following assemblies:

1. The film-handling system, comprising the intermittent or pulldown system, sprockets, film gate, and the takeup and rewind system
2. The optical system including the reflector, projection lamp, condenser lenses, and projection lens
3. The cooling system.

General Arrangement: A universal motor drives both the film-handling system and a coaxial 2½-inch squirrel-cage fan, *Fig.* 1. Its single speed of 4250 rpm is high enough to insure efficient control by an electrical governor, and also to induce a constant, adequate flow of air through the lamphouse. Belted to this motor and parallel to it, the shaft for the shutter and the pulldown cam rotates at 1080 rpm for silent-film speed and 1440 rpm for sound-film speed (18 and 24 frames per second, respectively). This shaft also carries a nylon worm, *Fig.* 2, for driving two nylon helical gears on the sprocket shafts, one above and one below. These are the only gears, and all three operate without lubrication. The film is driven by two sprockets, each having eight teeth. Since the film is advanced one frame per tooth, the sprockets are geared to rotate at ⅛ the pulldown shaft speed.

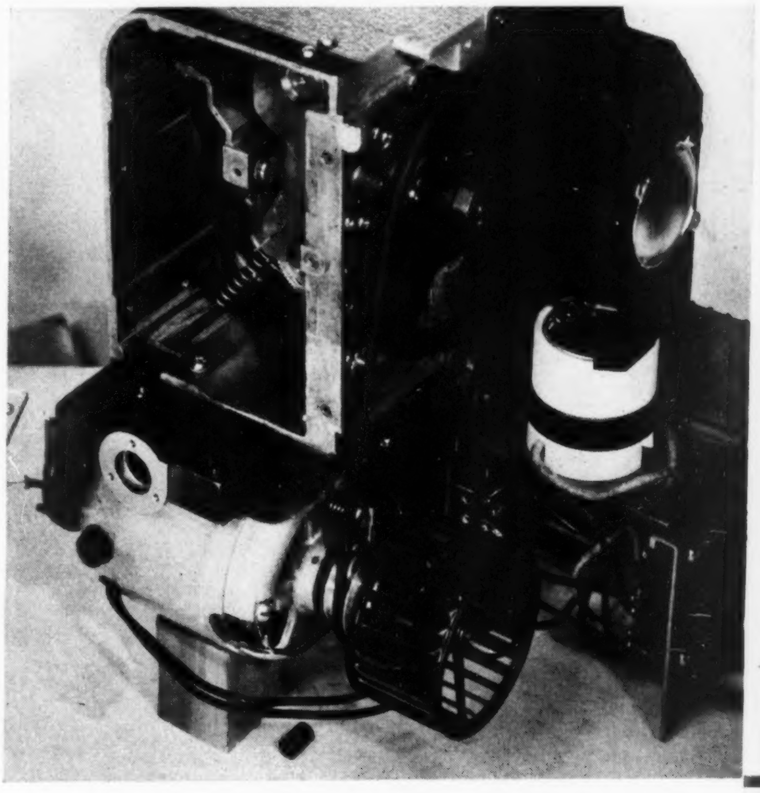
At the front end of the pulldown shaft is a knob that can be turned manually to aid in checking the threading of the film. A white dot on the knob is so placed that the operator can tell when the claw is retracted from the film and film gate.

Except for the flywheel, which is die-cast zinc, the whole film-drive housing, and supporting frames for the picture head, sound head and fan housing are die-cast aluminum for lightness, corrosion resistance, dimensional stability and sturdiness. Visible surfaces are finished with a light brown metallic wrinkle.

Pulldown: In any projector, the heart of the picture head is the pulldown mechanism. This mechanism determines the steadiness of the projected image, and is a prime factor in establishing the noise level of the projector. Sometimes, too, it establishes the interval between overhaulings. If the utmost in steadiness, life and quietness are to be realized, it is necessary to eliminate high-speed shafts, numerous gears, friction, the need for periodic lubrication (frequently forgotten), lumiere cams, skip-strokes, and problems caused by manufacturing tolerances.

In the Pageant, a pivoted arm for the pulldown

Fig. 1—A universal motor, belted to the shutter, drives the film-handling system of the Pageant. Cooling air is supplied by a squirrel-cage fan



claw, *Fig.* 3, makes possible the elimination of high-speed shafts, all but the minimum number of gears, the lumiere cam and the skip stroke, yet the provision of a cam of reasonable size in a suitable location. This arm is pivoted on an axis parallel to the axis of the lens and, because it must periodically enter and leave the film perforations, it must oscillate about a vertical axis, too. It must not, however, rotate about any other axis, and since any translation of the pivot axis is likely to cause unsteadiness of the projected image, the pivot cannot be set in rubber. A conventional universal joint with two mutually perpendicular axes would serve, but since any initial clearance in the trunnions or play developed through wear would cause unsteadiness and noise, a new type of ball-bearing pivot was developed. This pivot, shown in *Fig.* 3, operates without lubrication other than that applied at the factory. Noise and play are eliminated by using hard steel balls, hardened races and providing relief holes for the large pivot ball to prevent it from bottoming. The smaller balls roll. Lifetime lubrication is provided by an oil-saturated felt pad surrounding the pivot ball. This pad serves to prevent rust and to keep the pivot ball clean.

During the pulldown part of the stroke, motion of the claw is approximately harmonic, and although the return stroke is so slow that type of movement is of little consequence, it is also approximately harmonic. Before and after the stroke, the claw dwells for short periods so it can enter and leave the film perforations without interference. Dimensional requirements for this type of cam are much less severe than for the traditional lumiere cam. Because the arm of the pulldown claw is spring-pressed against the cam, a precise constant cam diameter, such as required for the lumiere, is not necessary, and no clearance problem ever develops. The rise of the cam, which determines length of the stroke, is the only precise dimension. A deviation in this dimension is multiplied by slightly less than two at the tip of the claw.

To operate smoothly with minimum wear, the cam surface must be free of ripples. This is accomplished easily by making the cam of burnished sintered iron (Super-Oilite). Impregnated with light turbine oil and mated with a nylon follower, the cam requires no further lubrication. This combination of materials has been found to be superior to any other combination tested, with or without periodic lubrication.

A coined brass cam, heavily plated with chromium, is used for the in-and-out motion. This cam receives adequate lubrication from the porous, oil-impregnated pulldown cam. The side of the nylon follower for the pulldown cam rides against the in-and-out cam, and thus only one follower is needed for both cams.

Even though the pulldown claw is made of hardened high-carbon steel, the claw tips are cyanided for additional resistance to the pronounced abrasive action of film. This treatment obviates the necessity for sapphire tips.

Shutter: To hold the pulldown and in-and-out cams in their proper angular positions with respect to the shutter, a small tab is formed on the shutter to fit into mating holes in the two cams. Made of steel, the shutter is also the driving sheave for the

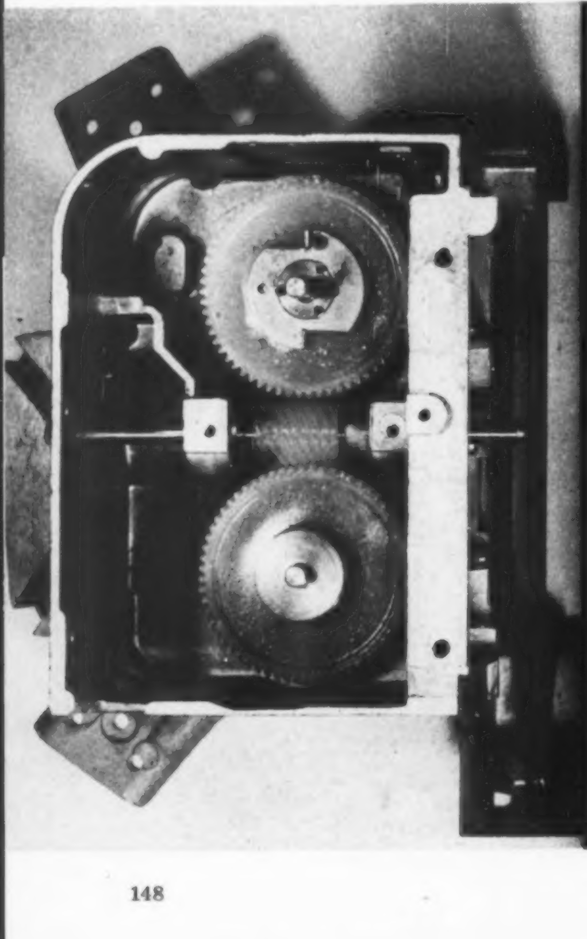
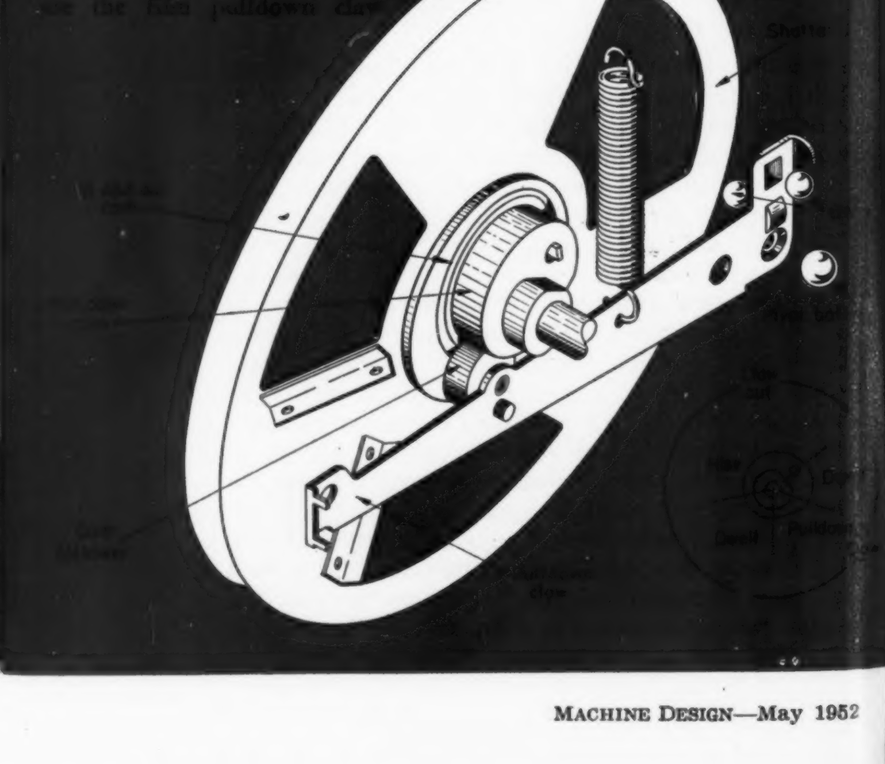


Fig. 2 — Left — Gears connecting the shutter shaft and film sprocket shafts are molded nylon for smoothness and quietness

Fig. 3 — Right — A combination of two simple cams operate the film pulldown claw



pulldown-cam shaft, and has an annular groove for a round-section belt rolled in its rim. The shutter has three blades, thus providing three interruptions of light for each frame of film, or a flicker frequency of 54 per second at silent speed and 72 per second at sound speed.

SHUTTER SHAFT: The shutter, the two cams, and a sealed ball bearing for the cam shaft are clamped against a small steel ring made of square wire, which is held snugly in a shallow groove in the 1/4-inch shaft by a small cup-shaped collar. This thrust shoulder arrangement permits making the full length of the shaft a constant diameter, thus simplifying the part and precluding eccentricity. The ball bearing eliminates shaft wear, the need for lubrication, and the radial clearance that would be necessary in a sleeve bearing. Serving a triple purpose, the ball bearing takes the pull of the belt, the load of the cam, and the thrust of the sprocket gears,

FRAMING: In order to allow the picture to be framed in the aperture of the gate, the claw pivot is mounted on an assembly that moves up or down when the operator turns the framing knob, *Fig.* 4. Thus the stopping position of the film with respect to the aperture may be changed and the outline of the aperture does not move on the screen. It is not necessary, therefore, to readjust the tilt of the projector after the picture has been framed.

OPTICAL SYSTEM: The optical system is a flexible one that utilizes a series of lenses and lamps which can be combined in various ways to suit widely different projection conditions. Five different lenses provide for short throws, long throws, large screens, small screens, wide-angle matte screens and narrow-angle specular screens.

Although the projector is normally equipped with a 750-watt lamp, a 1000-watt lamp can be substituted, for the optical system is cooled with a blast of air sufficient to protect it. For small or specular screens, lamps of lower wattage can also be inserted. Transverse adjustment of the lamp socket is possible so that the prefocused lamps can be adjusted to make the screen bright and uniform. Correct longitudinal placement of the lamp can be maintained without adjustment, as can the positioning of the Alzac aluminum reflector and the two-element condenser system.

SPEED CHANGER: Since the required cooling is independent of projection speed, it was found desirable to run the fan at a constant speed. This speed was chosen to provide effective cooling without introducing excessive noise from the blower—particularly important when sound is projected.

Speed of projection is changed by a mechanism that shifts the drive belt from one groove to another of different diameter. The dual aluminum pulley, *Fig.* 1, has a sloping connecting step which helps the elastic belt climb from the small pulley to the larger. A lever with a pair of Tenite rollers straddling the belt allows the operator, from his normal position in front of the other controls, to shift the belt. For durability with respect to both use and age, the belt is a 0.080-inch coiled spring enclosed in a molded layer of Neoprene, making a total outside diameter of 0.150-inch.

Sound Head: Consisting of a flywheel, a damping and isolating roller, and a sound-optical system, the

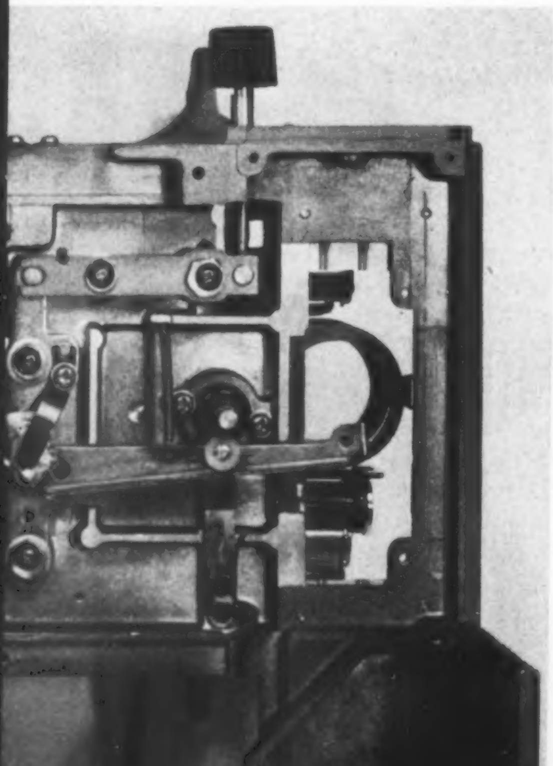


Fig. 4—Left—Film is moved up or down to frame the picture by shifting the ball pivot of the pulldown claw through a linkage arrangement

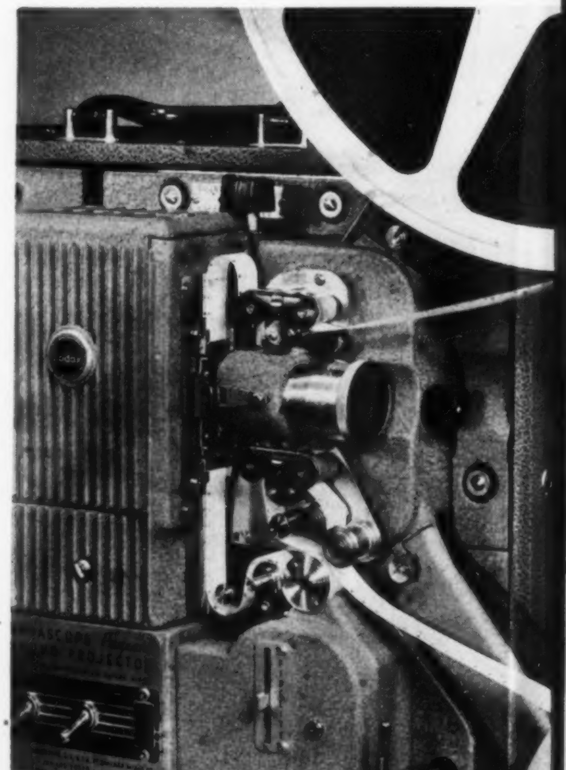


Fig. 5—Right — A simple threading path is followed by the film, which passes first above the upper sprocket, through the film gate, then around the sound drum and over the lower sprocket

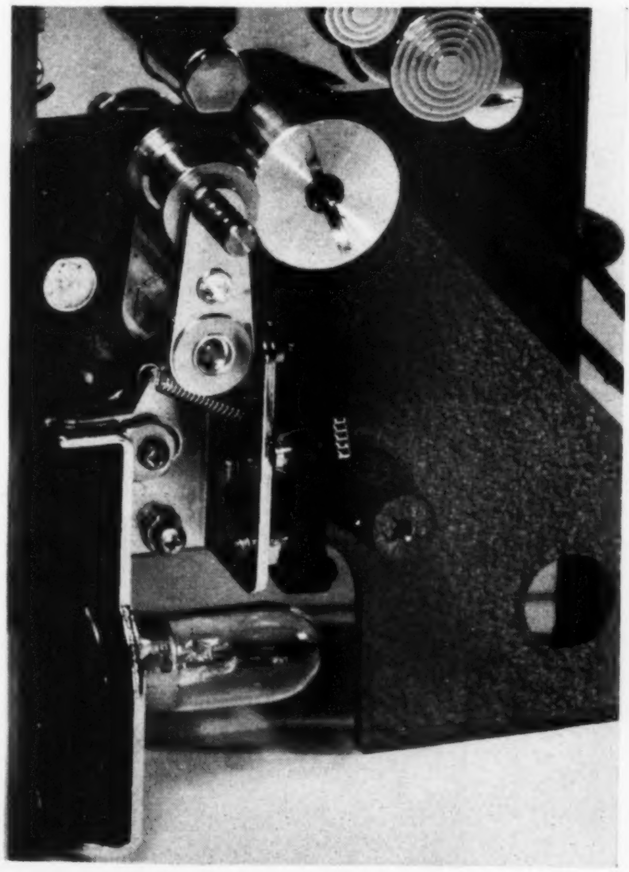
sound head smooths out the linear velocity of the film and scans the sound track.

GENERAL REQUIREMENTS: Good sound requires that variations in the speed of the film as it travels past the scanning point be kept to a low value to attain a satisfactorily low value of flutter. This velocity-stabilizing or filtering requires the following components: (1) inertia, which is provided by the flywheel; (2) elasticity, which comes from the loops in the film; (3) damping, which is provided by the isolating and damping roller. Low-friction, smooth-running bearings are also required.

Of the systems currently in use, most have two sprockets or complicated threading paths involving rollers, clamps, and tracks. Since many of the people who operate sound projectors have not had the opportunity to study mechanical filtering systems, they are baffled by any but the simplest threading path. This design, *Fig.* 5, was produced with sympathetic attention to the nontechnical operator, and interesting byproducts of the simplification of the sound system are low cost and sound with a consistently low flutter content.

FLYWHEEL: A 5-inch die-cast zinc flywheel provides the inertia. Its carefully balanced assembly is mounted at one end in a precision ball bearing that supports the weight of the flywheel, and at the sound drum end, near the scanning point, in a sintered bronze bearing. Holding force from the self-leveling pressure roller and wrap of the film around the sound drum, *Fig.* 6, allows the film to drive the drum without slipping over its surface.

Fig. 6—Holding force from an arm-mounted pressure roller helps the film drive the sound drum. The damping roller is shown at top left, and the sound optical system is below the sound drum



FILTERING AND DAMPING: Most of the isolation, particularly for the higher disturbing frequencies, is provided by bends in the film where it passes around a softly sprung damping roller, *Fig.* 6, mounted on the end of an arm. Damping is furnished by a sleeve filled with a silicone oil on the pivot of the damping-roller arm. When the arm of the damping roller is moved, shear in the oil between two cylindrical surfaces absorbs energy from the system.

SOUND-OPTICAL SYSTEM: An assembly of cylindrical lenses in a zinc die-cast mount focuses light from the exciter lamp on the film. By means of a fidelity lever which moves the complete mount, the operator can quickly get a critically sharp focus on either surface of the film. Thence, the modulated light enters a Lucite prism inside the sound drum and is transmitted to the phototube behind the casting.

Carrying Case: Of the original requirements, those calling for low cost, ease of operation, and light weight dictated that the entire outfit be housed and operated in a single carrying case. Since the projector is fastened to the case with only four screws, the whole projection mechanism can be easily removed for servicing. The elevation mechanism of the Pageant permits the operator to elevate the projector quickly by opening the elevation lock (*Fig.* 5, lower right corner), pressing lightly at the front of the projector to raise or lower the picture the required amount, and closing the elevation lock. When elevated the projector is quite stable laterally because the front foot is a cushioned bar more than 6 inches long. To this foot is fastened a vertical bar that rises nearly the full height of the case, through two slides fastened to the case. At the bottom bearing slide an eccentric locks the bar to the case. Fastened to the top slide and running to the top of the vertical bar is a large coiled spring that supports much of the weight of the front half of the machine. At maximum elevation, the projector is tilted about 11½ degrees.

In summary, the objectives originally outlined, which called for good sound and picture, quietness, simplicity, reasonable cost and universal operation have been realized in an assembly, weighing only 32½ pounds. This assembly is housed in a single case arranged so that the speaker can be separated and placed near the screen. Wear-and-tear tests have shown that the durability of the whole assembly meets the original specifications.

"A current plan for the young engineer should, first of all, include all of the activities that are necessary to round out engineering training to develop the engineer professionally and to make full use of his latent talents. After the young engineer has established himself and is recognized as an engineer of attainment, only then should he begin to devote some of the time at his disposal to enter a larger field of community activities that is useful, constructive and compatible with his background and mental development."—FRED T. AGTHE, *process engineer, Allis-Chalmers Manufacturing Co.*

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PRODUCTION AND
DESIGN
Modern Practices in Manufacture

Metal Stitching

—can help to reduce costs of fastening

METAL stitching can be used to join thin-section metals and nonmetals at high production rates without precleaning, drilling, punching, or hole alignment. In comparison with conventional joining methods, metal stitching makes possible production increases up to 700 per cent and material savings up to as high as 50 per cent.

Stitches are formed in one-fifth second and have high strength and durability. Wire cost is less than 1½c per hundred stitches. Substantial material savings are possible with metal stitching because only small flange areas are necessary; flange widths need be only ¼-inch.

Stitching operations are performed on high-speed power-driven machines and stitches are formed from continuous coils of high-carbon steel wire, *Fig.* 1.

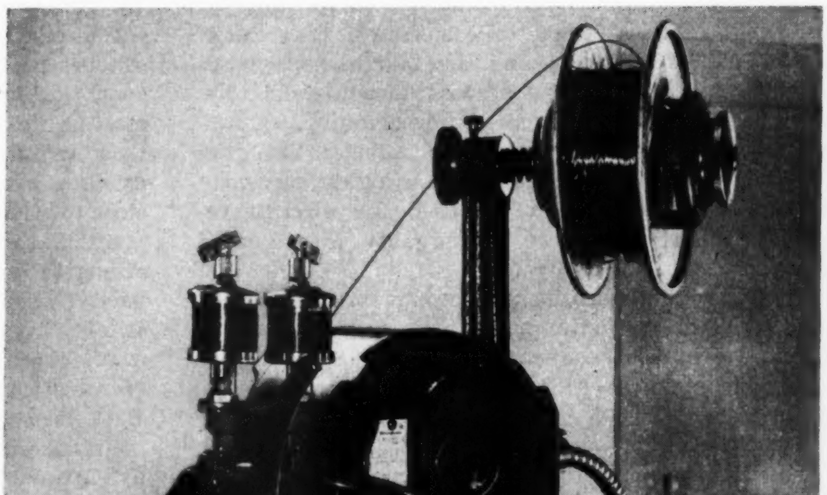


Fig. 1—Typical stitcher showing tubular part being fastened to wood plug piece

Various available models of metal stitchers have machine speeds ranging from 280 to 325 stitches per minute. Operating speeds are, of course, considerably lower than these rated speeds and on most production applications, range from 80 to 100 stitches per minute.

Wire: Stitching wire in common use falls into three Washburn and Moen sizes: 16-gage (0.0625-in.), 18-gage (0.0475-in.), and 20-gage (0.0348-in.). Tolerances on these wire diameters are plus and minus 0.001-inch and the wire is not more than 0.001-inch out of round.

As a general rule, four nominal are available: The first has a tensile strength range of 220,000 to 249,000

This article is based on material supplied by the Stitching Wire Div., Acme Steel Co.

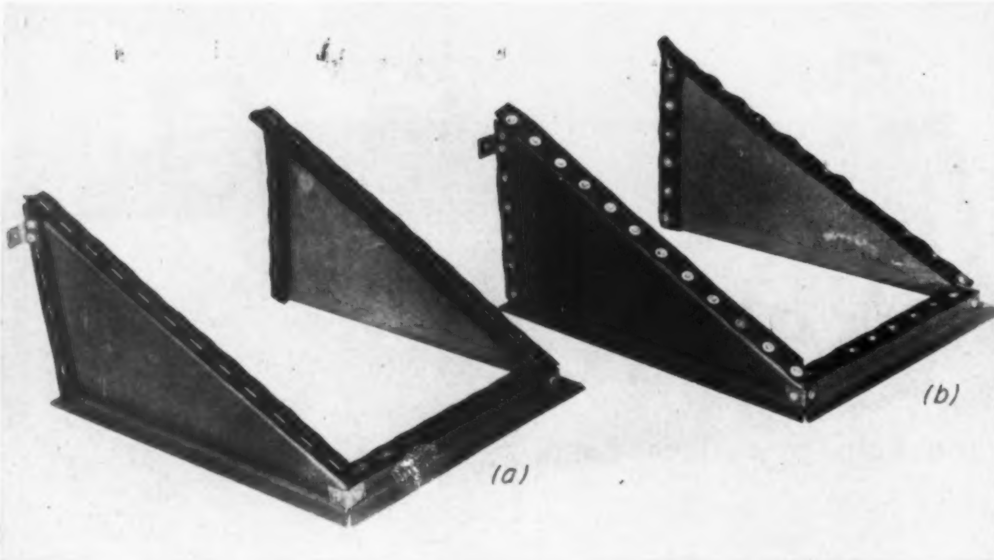


Fig. 2 — Aircraft part with felt strip stitched to metal form, *a*. At *b* is previous riveted design

psi; the second, 250,000 to 289,000 psi; the third, 290,000 to 319,000 psi; and the fourth, 320,000 to 360,000 psi. All sizes and grades can withstand 180-degree bends without fracturing or breaking. Standard commercial finishes available include: Tin, galvanized, liquor, or bright finish. A highly corosion-resistant zinc-coated wire is used for aircraft or other applications where this quality is required, *Fig.* 2.

For special applications, phosphor bronze, Monel and stainless steel stitching wire is used. Phosphor bronze wire most commonly used is 18-gage type S-54, and stainless AISI 302 in tensile strengths of 163,000 and 230,000 psi.

Clinches: There are two basic types of stitches used: the flat and the loop. Flat-clinched stitches have legs that lie flat against the bottom of the work. After the legs of these stitches penetrate the work, a clincher presses the legs flat against the bottom layer of material. Flat-clinched stitching machines are designed to handle work up to 25 inches from the column support and to produce clean crack-free holes, crowns flush with the top work surface to within 0.002 in., stitch legs flush with the bottom work surface to within 0.005-inch, and a maximum production penetration of two sheets of 0.040-inch, 24 ST aluminum alloy.

There are three types of loop clinches: The standard, the by-pass, and the outside loop clinch. A graphical comparison of the three loop-clinched stitches and a flat-clinched stitch is shown in *Fig.* 3. Loop-clinched stitches usually have $\frac{7}{16}$-inch crowns (crown is the inside distance between the legs). Both metallic and nonmetallic materials are fastened to sheet metal sections with these standard loop-clinched stitches.

The special by-pass and outside clinched stitches are usually furnished with ¼-inch crowns. The by-pass loop is used for assembling all types of metal and nonmetal combinations and is especially effective in attaching rods, small tubes, and springs to metal sections. The outside loop is used when it is desired to bury the stitching ends in nonmetallics.

Flat-clinched stitches have $\frac{7}{16}$-inch crowns. These stitches provide the highest ultimate strength. However, the flat clinch is unsuitable for heavy gages of steel or for over ¼-inch of nonmetallic materials. In these thicker materials, the legs of the stitch wander as they are driven through and tend to miss the close-tolerance guideways in the lower clincher.

Stitches with smaller crowns have increased column strengths which slightly increase the machine capacity. For this reason, the use of ¼-in. crown stitches is presently increasing. Also, stitches with smaller crowns have a better appearance. Special crown sizes from as small as ⅛-inch to as wide as 1.201 inch have been utilized.

Standard and special loop clinches are formed on five types of clincher profiles, *Fig.* 4. The tear-drop profile, type *a*, is used in nonmetal-to-metal combinations for clinching on the metal side. The two-groove

Recommended Material Thicknesses

	Metal to Metal (in., max each piece)		Metal to Nonmetal† (in., max each piece)
Aluminum, SO	0.093*	0.125	⅛ Sheet cork
Alclad or 24 ST	0.040*	0.064	⅜ Leather
Aluminum extrusion.	0.062*	0.093	¼ Sheet Asbestos
Cold-rolled steel, 1010	0.050**	0.078	½ Fiber
Hot-rolled steel	0.037**	0.062	½ Sponge rubber
Galvanized steel	0.037**	0.050	¼ Solid rubber
Stainless, full-hard .	0.010	0.020	⅛ Phenolics§
Stainless, ½-hard ..	0.012	0.025	$\frac{3}{16}$ Plastic§
Stainless, ¼-hard ..	0.015	0.030	⅜ Standard Masonite
Stainless, annealed .	0.020	0.040	¼ Tempered Masonite
Sheet brass, soft ...	0.030	0.050	⅜ Wood‡
Sheet copper	0.035	0.064	

† Any nonmetallic listed may be employed with each metal but maximum combinations may not always be feasible.

* Flat or loop clinch—all others loop clinch only.

** Rockwell 50 on B scale or softer.

§ Must be soft enough to penetrate without cracking.

‡ Over ⅜ thickness, grain structure may cause leg to wander.

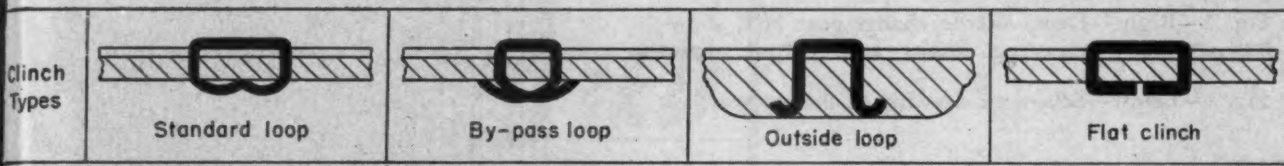
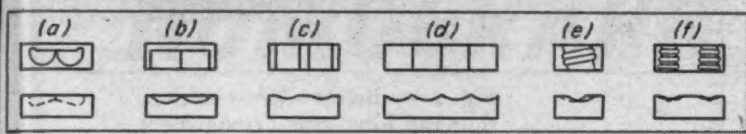


Fig. 3—Above—Basic types and sizes of clinches
Fig. 4—Below—Various clincher profiles utilized in stitching



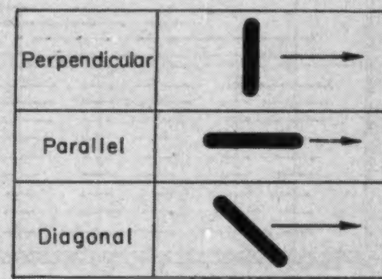


Fig. 5—Right—Orientation of stitches with respect to load. Diagonal type is preferred

profile with one end closed, type *b*, is for joining both metals and nonmetals to thin metal sections and clinching on a metal side. Both the two-groove open profile, type *c*, and the four-groove open profile, type *d*, are used in metal-to-nonmetal combinations when it is desired to embed the standard loop clinch in the nonmetallic material.

The by-pass profile, type *e*, is used primarily to form ¼-inch crown by-pass stitches around bars and tubing up to ¼-inch diameter. However, this type can also be used to clinch on flat metal. The outward clinch profile, type *f*, is used to embed ¼-inch crown outward-clinch stitches in nometallic materials. The extra row of grooves makes it possible to properly clinch the legs of the stitches even if they wander, as in grainy materials.

Strength of Stitched Joints: In addition to the fact that stitches can be loop or flat clinched, they can be applied to the work pieces either perpendicular, parallel, or diagonal to the line of pull, *Fig.* 5. Perpendicular and diagonal stitches have higher shear strengths than parallel stitches. Loop clinches average about 75 per cent of the strength of flat clinches shown. Whenever the yield strength of nonmetallic material to be stitched is less than that of the stitching wire, the strength of the loop clinch is more than adequate.

Stitchable Metals: The most frequently stitched metals are: Heat treated, clad and extruded aluminum; cold-rolled steel; galvanized sheets; full-hard, ½-hard, ¼-hard and annealed stainless steel; soft sheet brass, and sheet copper.

The most frequently stitched nonmetallic materials are: Sheet cork, leather, sheet asbestos, fiberboard, standard and tempered Masonite, sponge and solid rubber, phenolics and other plastics, solid wood and plywood. The accompanying table gives the recommended maximum stitchable thicknesses for these materials.

Frequently, these maximums can be exceeded. However, in instances where the metal has been work-hardened through forming, the recommended maximum thicknesses may be impossible to stitch. Another factor affecting stitchable thicknesses is the condition of the machine. Most of the thicknesses tabulated are for parts stitched with 18-gage, grade 330 wire. Wherever possible, the lowest satisfactory tensile-strength wire should be used in order to keep machine maintenance at a minimum.

Hydraulic Generator Rotor

POISED over the heads of a G-E field engineer and a Finnish power company representative, the huge iron umbrella shown is actually the rotor for a hydraulic generator. Two of the water-wheel generators have been built for installation in the towns of Leppiniemi and Imatra, Finland. Each rotor weighs approximately 230 tons.

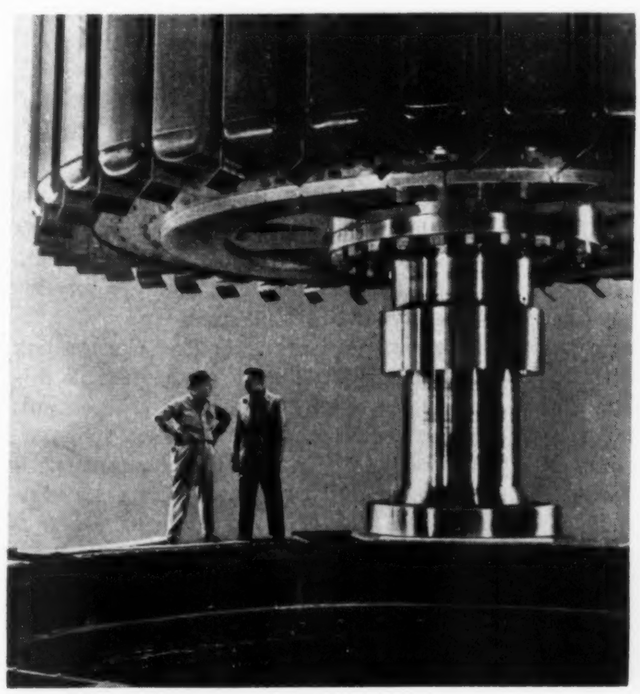


Fig. 1—Right—Deuta-Werke change-gear box, showing counters, adjusting knobs and output shafts

Fig. 2—Below—Schematic drawing of change-gear box

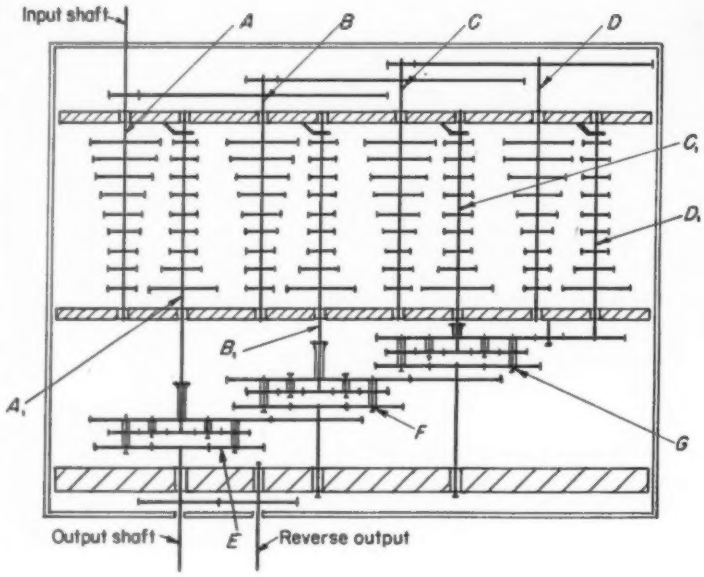
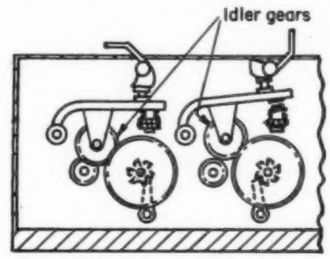


Fig. 3 — Below—Cross-section, showing idler-gear arrangement and pawl and ratchet gear



Change-Gear Box Has Wide Range

By Paul Grodzinski *Mechanical Engineer, London, England*

A PRECISE known speed is often necessary in the testing and calibrating of instruments. As one means of adjusting instrument speeds with high accuracy over a wide range, a German firm has developed the change-gear box shown in *Fig.* 1. This gearbox can, with appropriate input, produce any integral output speed from 1 to 9999 rpm.

In principle the box is a multiple-gear change box with four shafts of stepped gears connected by differential planetary gears which "sum up" the output. In this Deuta-Werke arrangement, shown schematically in *Fig.* 2, shaft *A* is driven by a constant-speed motor. Shaft *B* is geared to *A* so that its speed is reduced to one-tenth that of *A*, and shafts *C* and *D* are geared down in the same ratio.

Each of these driving shafts carries nine gear wheels, which are coupled to corresponding gears on driven shafts A_1, B_1, C_1, or D_1 by a movable idler gear. By selection of the proper pair of gears, speed of the driven shaft can be reduced in equal steps. Thus shaft A_1, with the proper input, can represent the "thousand rpm" output, with individual speed changes in steps of 1000 rpm; shaft B_1 becomes the "hundred rpm" output and so on.

Driven shafts are connected to the sun wheels of planetary differentials *E, F* and *G,* whose carriers are geared to the output of the previous planetary. Thus the speed of the final output shaft represents the sum of the speeds of all shafts.

Idler gears, *Fig.* 3, are carried on a swinging arm which can first be shifted axially from gear to gear, and then be fixed in position. Four adjusting knobs, connected to counters showing the output speed, shift the arm to the desired pair of gears. When driving and driven shafts are not coupled, giving zero output for the particular set of gears, the driven shaft is prevented from rotating backward by a pawl and ratchet gear, *Fig.* 3, or by a free-wheeling clutch.

SIMPLIFIED NOMOGRAPH CONSTRUCTION

. . . for predicting design factors and cutting development costs

By John Baude
Allis-Chalmers Mfg. Co.
Milwaukee, Wis.

DETERMINING optimum properties or predicting performance of new products often cannot be done on a purely rational basis. A thorough-going theoretical analysis may be almost impossible, or at best, extremely tedious—and results frequently are of questionable accuracy.

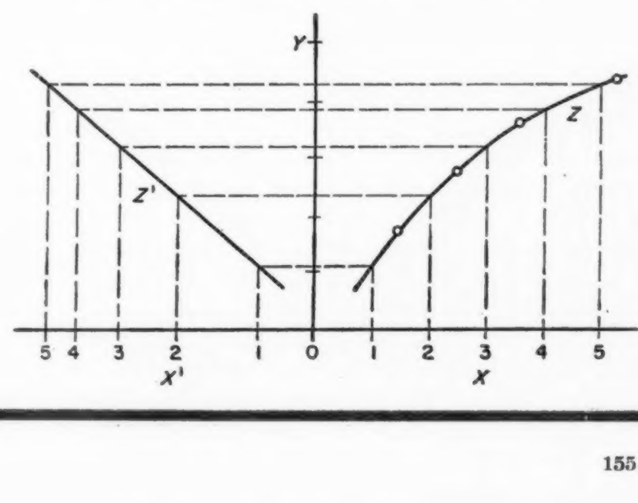
In many circumstances, adequate accuracy with minimum labor can be obtained by utilizing known properties or test data of existing products. Application of such methods implies, of course, that the characters of the systems, both existing and new, are essentially of a common order. This restriction usually imposes no limitation on size, operating range, and other pertinent qualities.

When only two variables are involved, the problem is relatively simple. Interpolation, or extrapolation, of a plotted curve often suffices, or an empirical equation can be developed. Three variables or more, however, pose a greater problem. The usual graphical procedure requires plotting of curve families and interpolation, or extrapolation, both along the curves—between known points—and between the curves. Or again, an empirical relationship can be formulated, but the right expression is not always easily found.

Possessing greater facility in everyday use than curve families, nomographs can often be developed by simple graphical procedures without recourse to mathematical analysis. A nomograph, or alignment chart, for three variables consists simply of three scales that are so arranged and marked that a straight line through them strikes three values which satisfy the equation relating the variables. This article presents a method for the graphical transformation of curve families into three-scale nomographs.

Transforming Curves into Straight Lines: The first step is to transform curves of existing data into straight lines. A single curve in a co-ordinate system can be transformed into a straight line by distortion of the scale on one axis. This action is demonstrated in *Fig.* 1 where curve Z is reproduced as a straight line Z' of any arbitrary slope. Scale values of the new X' co-ordinates are found by simply projecting from the original X values as shown. Hence, a curve

Fig. 1—Transforming a curve into a straight line by distortion of one co-ordinate scale



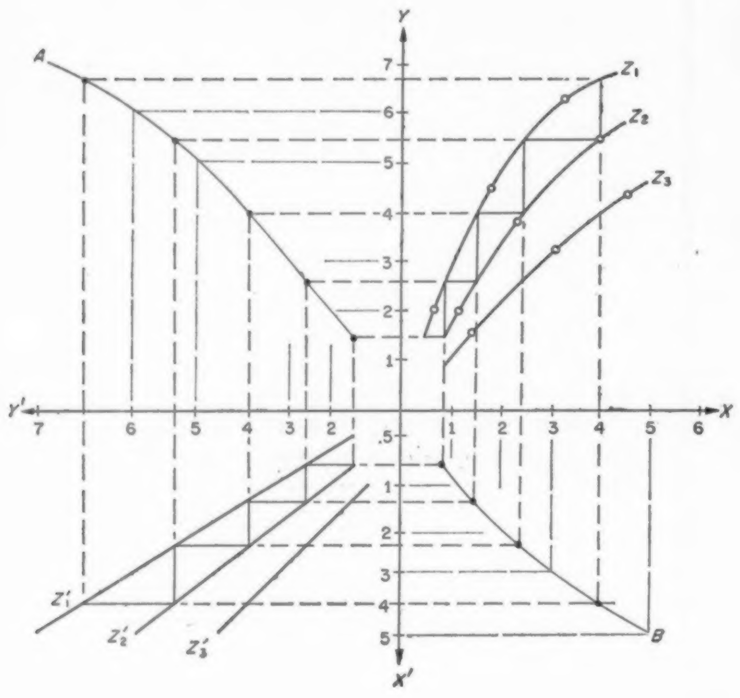
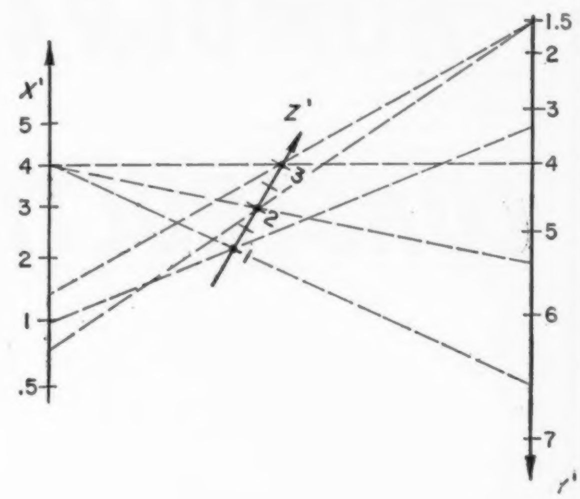


Fig. 2—Left—Construction for transformation of curves into straight lines by scale distortion of X'-Y' co-ordinates

Fig. 3—Below—X'-Y' scales from *Fig.* 2 transferred and employed for nomograph scales. Construction of Z' scale is indicated by dashed lines



becomes a straight line with a distorted X' scale and an unchanged Y scale.

Somewhat similarly, two curves can be converted to two straight lines by distortion of both co-ordinate scales. This transformation is shown in *Fig.* 2. For convenience, reference will be made to this graph in terms of quadrants (first, second, etc.), although it should be observed that designations of the distorted axes are not conventional in relation to their positions.

Two straight lines, Z_1' and Z_2' are drawn in the third quadrant in a similar direction and position to curves Z_1 and Z_2 in the first quadrant. These lines represent the curves Z_1 and Z_2 in the new X', Y' co-ordinate system.

Horizontal and vertical lines resembling steps are drawn at random between Z_1 and Z_2 curves and between the Z_1' and Z_2' curves starting as close to the zero point as possible. The vertical lines between Z_1' and Z_2' are extended through the second quadrant. The horizontal lines between Z_1 and Z_2 are also extended through the second quadrant. Curve A is then drawn through the intersecting points of the vertical and horizontal lines in the second quadrant. Curve B is constructed in a similar manner in the fourth quadrant. Scale points on the Y axis are projected to the curve in the second quadrant. Lines are drawn from these points of intersection to the Y' axis to obtain the Y' scale points. The X' scale is constructed in the same manner.

The Z_3' curve is independently plotted from the source data in relation to the Y' and X' axes. If the result is a straight line or nearly so, the procedure is sufficiently valid and a nomograph of reasonable accuracy can be developed. If Z_3' is not a straight line, some necessary premise of the procedure is not present. Either the original data are erratic, or the properties of the systems being compared are not of a common or uniformly progressing order. The latter complication may either preclude any logical linking of the data or may necessitate use of more involved methods for mathematically relating the variables. A study, such as that of *Fig.* 2, quickly indicates the wisdom of proceeding with the development, or abandoning it.

To obtain the best possible accuracy, X and Y scales usually should be chosen to make the Z curves as straight as possible, consistent with practical scale dimensions. It is also desirable to choose two curves in close proximity, rather than widely separated, so that there will be a greater number of steps between curves. In fact, the curves must be close enough to permit three pairs of transfer points to be established without excessive extrapolation; otherwise, the procedure is ineffective.

If equal original increments for the X and Y scales result in curves which are practically horizontal, it is obvious that the X scale should be compressed or the Y scale extended to give the curves more slope and increase the number of steps between them. Ideally, of course, the curves should tend to have a general slope of 45 degrees. Such a practice will also make the construction and use of curves A and B more accurate.

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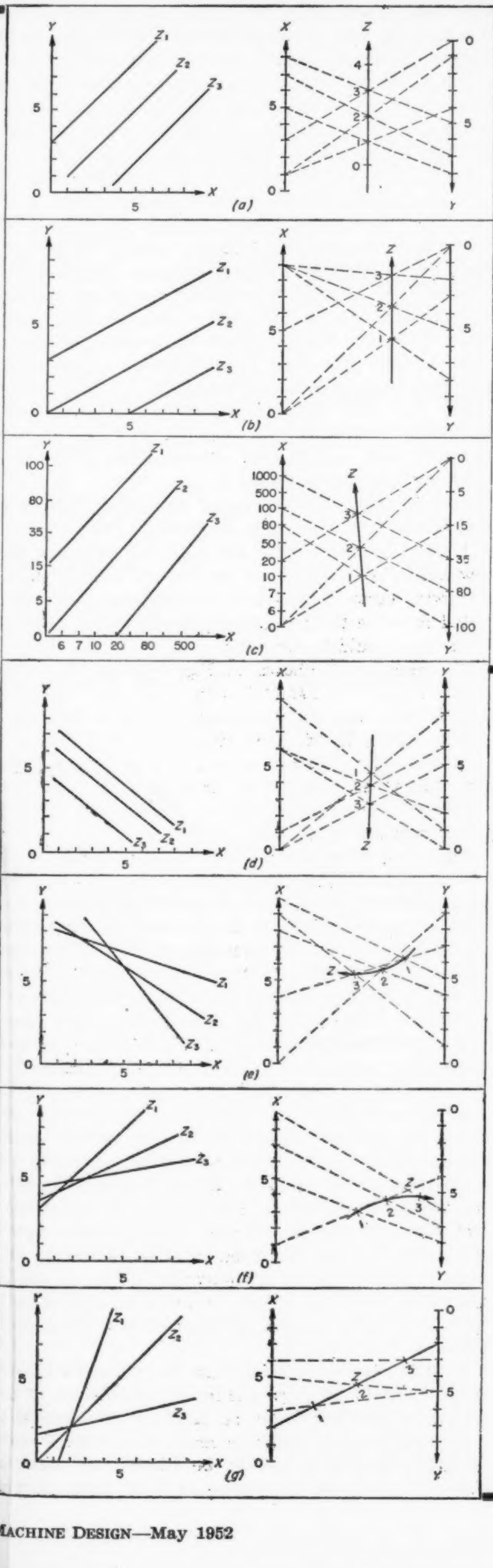
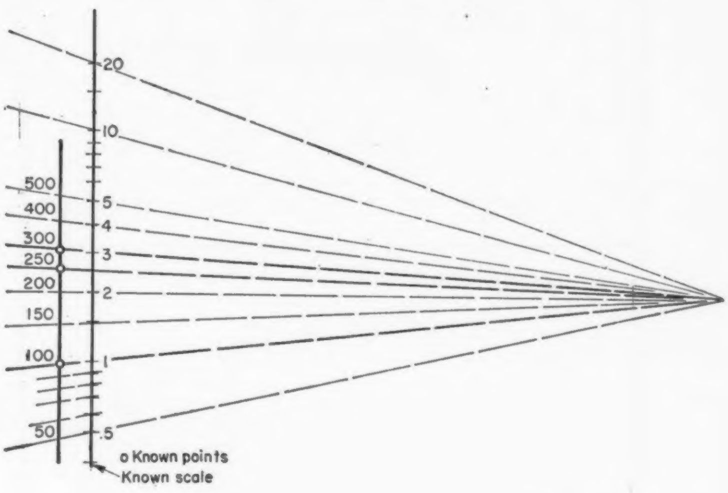


Fig. 4—Left — Typical nomographs prepared from co-ordinate transformations. These samples are useful reference for determining polarity of Y relative to X and relative locations of scales

Fig. 5—Below—Method of expanding exponential scales by utilizing a known scale



Transferring Scales to a Nomograph: A nomograph in its simplest form consists of three scales representing three variables. These three scales are so located and marked that a straight line drawn through them will mark three points which represent simultaneous values of the three variables.

The nomograph in *Fig.* 3 is constructed directly from the straight-line plot in the third quadrant of *Fig.* 2. The X' and Y' scales of the nomograph are simply the X' and Y' axes of *Fig.* 2, drawn parallel and separated by any arbitrary distance. The Z' scale is constructed graphically by use of data obtained from *Fig.* 2. Each principal scale point on Z' is located by the intersection of two lines, each connecting values of X' and Y' known from *Fig.* 2 to hold for the desired value of Z'. The dashed lines in *Fig.* 3 demonstrate this procedure.

Curve Z_1' is used to obtain point 1, curve Z_2' to obtain point 2, etc. The Z scale is established simply by joining the points with a smooth curve.

The direction of increasing values for Y relative to X must be properly selected. The typical cases shown in *Fig.* 4 serve as a guide on this detail. If the two lines joining X and Y points for finding a Z point fail to intersect, the polarity of one scale must be inverted.

Usually the Z scale is a straight line. However, if the Z lines in the graph intersect each other in several points, such as in *Figs.* 4*e* and 4*f*, the Z scale is a curve.

With this method of obtaining a nomograph only three points are obtained for the Z' scale. To make use of the nomograph, a full scale must be developed.

Table 1—Maximum Loads for Helical Springs*
(Test data in pounds)

Dia. of Wire (in)	Outside Dia. of Spring (in.)									
	2¾	3	3½	4	4½	5	5½	6	6½	7
½	1613	1500	1308	1160	1041	941	857	788		
9/16	2250	2095	1836	1632	1472	1328	1214	1118	1033	
5/8	3000	2805	2490	2202	1993	1811	1659	1521	1417	
11/16	3916	3722	3253	2915	2635	2398	2188	2020	1875	
¾		4660	4140	3750	3390	3054	2836	2618	2424	2258
13/16			5190	4660	4250	3860	3557	3275	3055	2832
7/8			6330	5720	5240	4810	4420	4085	3805	3525
15/16				6945	6360	5840	5360	4970	4640	4335
1				8280	7590	7000	6460	6000	5590	5215
1⅛					10470	9710	9000	8410	7810	7340

* From Machinery

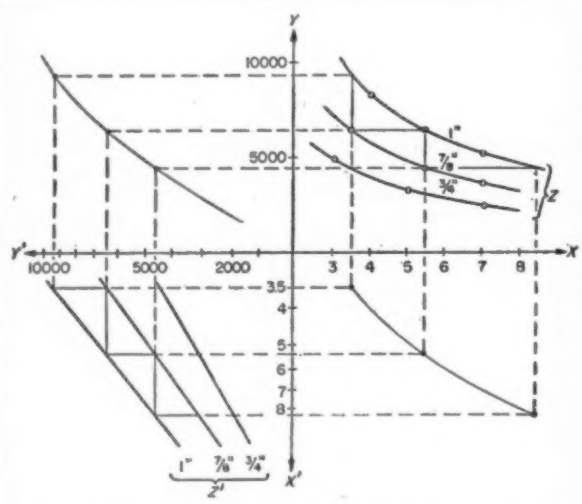
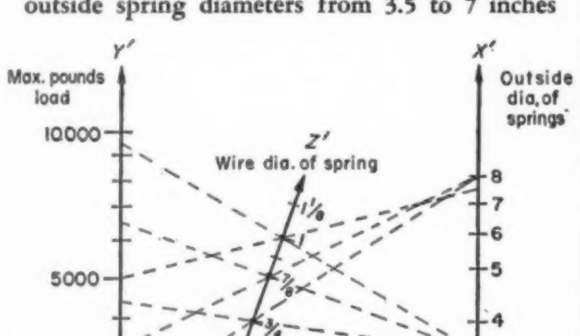


Fig. 6—Above—Test data from Table 1 plotted as conventional curves in first quadrant and transformed to straight lines in third quadrant. Outside diameter is plotted as Z, diameter of wire as X and max load as Y

Fig. 7—Below—Nomograph prepared from test data and analysis as shown in *Fig.* 6 and Table 1 for ½ to 1⅛-inch wire diameter having outside spring diameters from 3.5 to 7 inches



Some scales, are linear or nearly linear and can be expanded by proportioning the spaces between scale points. However, scales may be exponential, logarithmic, or other functions. These scales may be filled in by the method shown in *Fig.* 5. Known exponential scales can be easily constructed and logarithmic scales may be taken from a slide rule.

Application of this method of expanding known data to a common problem shows its usefulness.

Solving Spring Problems: Spring data shown in TABLE 1 was obtained by testing a total of 80 springs. High cost of such work with these heavy-gage springs could be reduced greatly by careful graphical analysis of only nine actual test points. For practical purposes, these nine tests eliminate the need for all other tests, as will be shown by comparison of graphical data with actual test data in TABLE 1.

The test data selected and shown in *Fig.* 6 are marked as reference points on the wire size curves, 1-inch, ⅞-inch, and ¾-inch, corresponding to the nine numbers indicated in TABLE 1.

Transformation of the curves into straight lines is accomplished as previously explained. Curves for ⅞ and 1-inch diameter wire are used for obtaining the new scales. With the new scales, the ¾-inch diameter wire curve becomes a straight line when projected into the third quadrant, showing that consistent results could be expected.

The nomograph shown in *Fig.* 7 gives all spring data contained in TABLE 1 with reasonable accuracy. Interpolation and extrapolation to obtain wire sizes of 1⅛, 15/16, 13/16, 11/16, 9/16 and even ½-inch is easy and errors do not exceed plus or minus 5 per cent. In most cases, it is far below this value. A wealth of spring data can be quickly and readily taken from this nomograph.

Assuming that ⅞-inch wire is not available at present but a 15/16-inch diameter wire is available, the spring will be loaded to a maximum of 5000 lb at 100,000 psi stress. What is the outside diameter of the spring? From the nomograph, *Fig.* 7, a 6-inch diameter is required. Actual tests give 4970 psi or an error of 0.6 per cent. Spring deflection data can be treated in a similar manner, and a second nomograph could be prepared to give deflection data corresponding to load, wire size and spring diameter.

Suitability of Data: It is desirable to predict as soon as possible whether or not all curves can be presented as straight lines in the third quadrant of the co-ordinate system. Curves which are similar in appearance and run fairly parallel to each other usually will plot as straight lines in a co-ordinate system with two distorted scales. Curves such as sine curves which change their direction must be treated in two parts. If only test data are available they should be plotted in curve form first in order to determine if they are erratic, or can be based on a mathematical formula.

A little experience along this line will show how to judge a family of curves from the standpoint of determining whether it can be used for preparation of a nomograph. In order to make this system work properly, test data should be plotted as soon as data are available to outline at least three curves.

Analyzing Accelerations of Complex Mechanisms

. . . how conventional polygon methods can be applied to floating-link systems

By R. T. Hinkle
Professor of Mechanical Engineering
Michigan State College

Mechanisms containing more than one floating link usually present a challenge to the designer when an acceleration analysis is required. In many such complex mechanisms, acceleration problems have often been left unsolved in the past. Kinematics texts usually contain discussion of the polygon method of acceleration analysis for simple mechanisms. However, such discussion frequently is not adequate for analysis of linkages such as those shown in *Figs.* 1 and 2.

Several methods have been developed[1,2] for solving acceleration problems of this type. However, these methods diverge somewhat from the usual acceleration polygon method, or as it is sometimes called, the relative acceleration method. Today mechanisms are becoming more complex and operating speeds are increasing. Hence, in contrast with the past, need for effective analysis is becoming more critical. Introducing no new basic concepts, this article demonstrates how the conventional polygon method can be extended for the solution of certain more complex mechanisms. Procedures can be most easily outlined by solution of several problems.

In the first example, *Fig.* 1*a*, the problem is to determine the acceleration image of link 4. The angular velocity ω_2 and acceleration α_2 of link 2 are known. The velocity polygon is shown in *Fig.* 1*b*. The velocity of *B* relative to the frame is calculated and laid off as *ob*. The motion of *D* relative to *B* is perpendicular to *DB*. A line through *b* in this direction will contain *d*. A line through *o* perpendicular to link 5 will contain *e* and a line through *o* perpendicular to link 6 will contain *c*. The velocity image of link 4 will be perpendicular to *EDC* and its ends will lie on the lines containing *e* and *c*. A trial solution e_1c_1 is drawn, and d_1 is located by proportions. A line through d_1 and the intersection of the lines containing *e* and *c* (in this case pole *o*) is the locus of d_1 for all trial solutions. The intersection of this line with the previously determined line containing *d* locates *d*. The image *edc* is then drawn.

The acceleration polygon is shown in *Fig.* 1*c*. Normal and tangential accelerations of *B* with respect to *O*, $_nA_{BO}$ and $_tA_{BO}$, are calculated and laid off from pole *o*′. Next, $_nA_{DB}$ is calculated, from the velocity obtained in the velocity polygon, and laid off from point *b*′. The perpendicular at the terminus will contain $_tA_{DB}$ and point *d*′. Then $_nA_{CG}$ is calculated and laid off. The perpendicular at the terminus will contain $_tA_{CG}$ and *c*′.

A portion of the polygon is shown in *Fig.* 1*d*. For purposes of explanation it will be assumed that point *d*′ is known. Point *e*′ can be located by laying off $_nA_{ED}$ (shown dotted) and drawing a perpendicular at the terminus. The intersection of this perpen-

[1] References are tabulated at end of article.

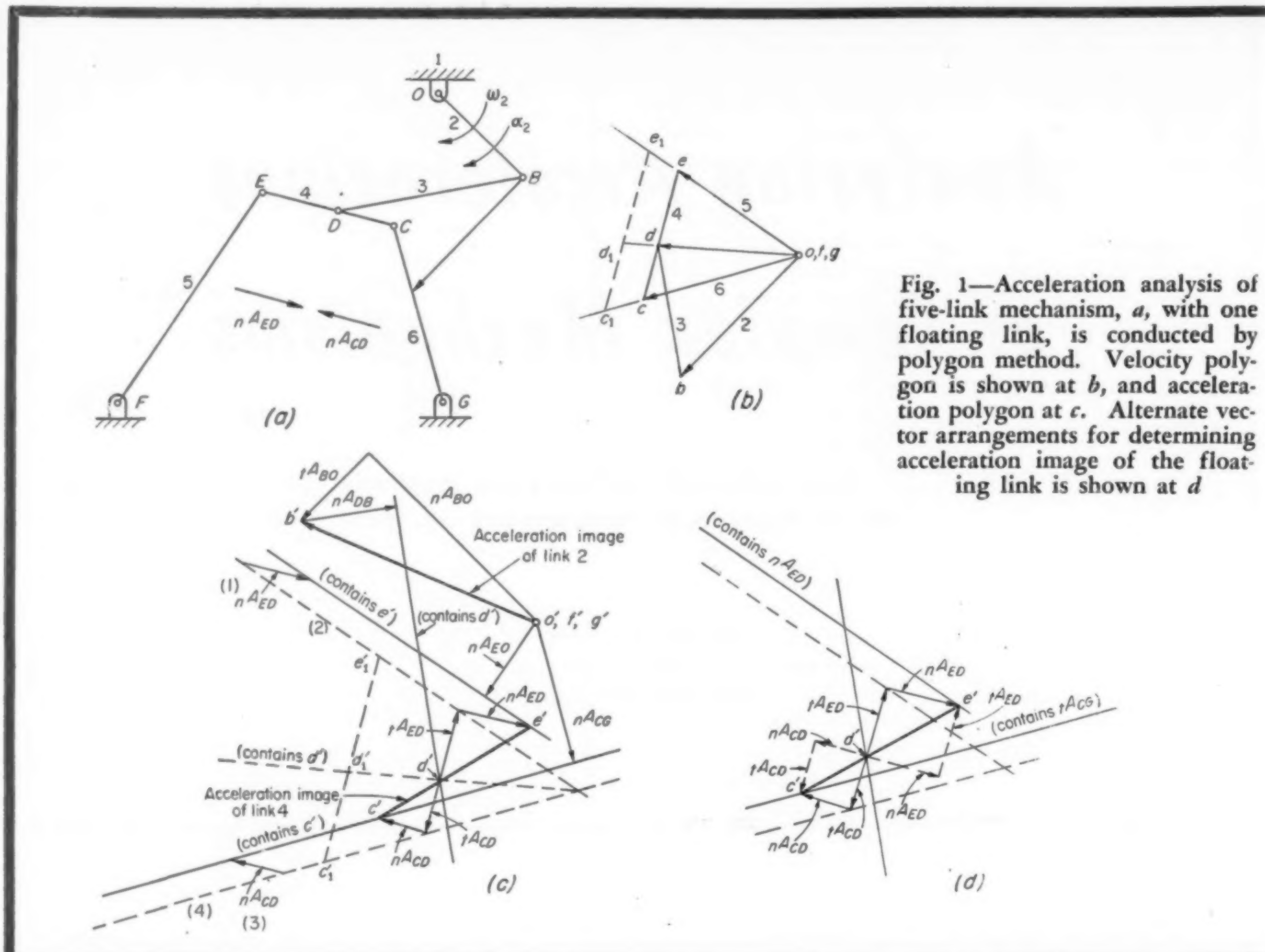


Fig. 1—Acceleration analysis of five-link mechanism, *a*, with one floating link, is conducted by polygon method. Velocity polygon is shown at *b*, and acceleration polygon at *c*. Alternate vector arrangements for determining acceleration image of the floating link is shown at *d*

dicular and the line containing e' locates e' and determines the magnitude of $_tA_{ED}$. Point c' can be found in similar manner. The vectors can also be arranged in a different manner. Acceleration $_tA_{ED}$ (shown solid) can be drawn from d' and $_nA_{ED}$ (shown solid) can be drawn perpendicular to terminus of $_tA_{ED}$. The latter arrangement must be used in making a trial solution.

Referring again to *Fig.* 1*c*, $_nA_{ED}$, shown at (1), is laid off in its proper direction with its terminus touching the line containing c' at any point. A line (2) is drawn through the origin of $_nA_{ED}$ parallel to the line containing e'. Then, $_nA_{CD}$ is laid off at (3) such that its terminus touches the line containing c'. A line (4) is drawn through the origin of $_nA_{CD}$ parallel to the line containing c'. A trial solution for the tangential accelerations can now be made. A line $e'_1\,c'_1$ is drawn between lines (2) and (4) perpendicular to the original line *EDC* of *Fig.* 1*a*. Next, d'_1 is located by proportions. A line through d'_1 and the intersection of lines (2) and (4) will contain points d'_1 for all trial solutions. The intersection of this line with the other line containing d' locates d'. The correct value of $_tA_{ED}$ and $_tA_{CD}$ can be drawn and the acceleration image of link 4 determined.

As another example, a mechanism that is equivalent to the Walschaert valve gear is shown in *Fig.* 2*a*. To reduce the number of lines in the solution, some of the links involving only simple theory have been omitted. Link 2 has been given arbitrary angular velocity and acceleration ω_2 and α_2. Slider *G* has been given arbitrary linear velocity and acceleration V_G and A_G. The velocity polygon is shown in *Fig.* 2*b*. Its construction requires the use of simultaneous trial solutions. The known linear velocity V_G is laid off as *og*. V_{B2} is calculated and laid off as ob_2. A line through the terminus of b_2 in the direction of sliding of B_3 relative to B_2 will contain b_3. A line through pole *o* perpendicular to link 4 will contain *c*. A horizontal line through *o* will contain *e*. A trial solution for link 3 is made. First, $b_{3\text{-}1}\;c_1$ is drawn perpendicular to link 3. Then, d_1 is located by proportions. A line through d_1 and the intersection of lines containing *c* and b_3 will be the locus of d_1 for all trial solutions for link 3. A trial solution for link 5, f_1e_1 is made perpendicular to link 5 and d_2 is located by proportions. A line through d_2 and the intersection of lines containing *e* and *f* will be the locus of d_2 for all trial solutions of link 5. The intersection of the lines containing the trial points d_1 and d_2 will locate *d*. Then, lines *def* and dcb_3 are drawn.

The acceleration polygon is shown in *Fig.* 2*c*. Its construction requires simultaneous trial solutions for links 3 and 5. The construction is made in the following manner. Vectors $_nA_{B2\text{-}K}$, $_tA_{B2\text{-}K}$ and $2V_{B3\text{-}B2}\omega_2$ are determined and laid off as shown. A perpendicular

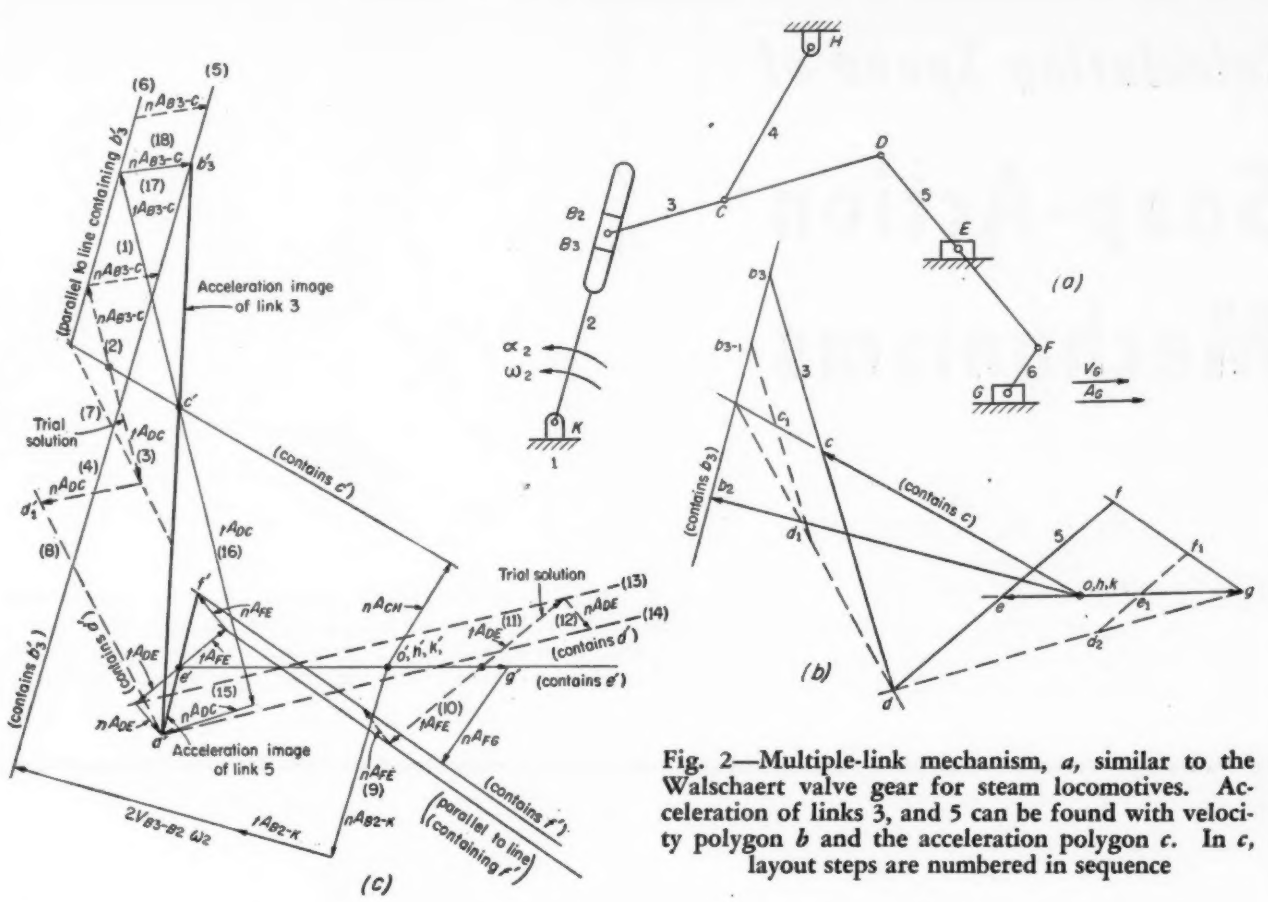


Fig. 2—Multiple-link mechanism, *a,* similar to the Walschaert valve gear for steam locomotives. Acceleration of links 3, and 5 can be found with velocity polygon *b* and the acceleration polygon *c.* In *c,* layout steps are numbered in sequence

at the terminus of $2V_{B3\text{-}B2}\omega_2$ will contain ${}_tA_{B3\text{-}B2}$ and hence b'_3. Now ${}_nA_{CH}$ is determined and laid off. The perpendicular at the terminus contains ${}_tA_{CH}$ and c'. Next, A_G is laid off as $o'g'$. E has horizontal motion and hence e' will lie on a horizontal line through o'. Than, ${}_nA_{FG}$ is determined and laid off. The perpendicular at the terminus contains ${}_tA_{FG}$ and f'. Information is now available for making the trial solutions. Link 3 will be considered first. Vector ${}_nA_{B3\text{-}C}$ is calculated and laid off in any position having the correct direction and its terminus on the line containing b'_3. The position chosen is shown at (1). The perpendicular distance between the origin of the vector and the line containing c' is a trial value for ${}_tA_{B3\text{-}C}$. This is shown at (2). At (3) ${}_tA_{DC}$ is determined from ${}_tA_{B3\text{-}C}$ and the proportions of link 3. Next, ${}_nA_{DC}$ is calculated and laid off at (4). This locates a trial position for d' shown as d'_1. If a second trial solution is started ${}_nA_{B3\text{-}C}$ will be laid off at some position such as (5). The line (6) through the origins of these two vectors will be parallel to the line containing b'_3. It is therefore not necessary to make a second trial solution. Line (6) is drawn through the origin of the vector (1) parallel to the line containing b'_3. A line (7) through the terminus of vector (3) and the intersection of line (6) and the line containing c' will contain the termini of all trial solutions for ${}_tA_{DC}$. Line (8) through the terminus of vector (4) and parallel to line (7) will contain all trial points d'_t. In a similar manner a trial solution is made for link 5. Vectors for the trial solution are (9), (10), (11) and (12) and are laid off in that sequence. Line (13) is drawn in the same manner as line (7), and line (14) containing d' is parallel to line (13). The intersection of the two lines containing d' locates d'. The acceleration image of link 3 can now be determined by constructing the correct vectors (15), (16), (17) and (18), starting from d'. The acceleration image of link 5 is made in a similar way.

REFERENCES

1. A. S. Hall and E. S. Ault—"Auxiliary Points Aid Acceleration Analysis," MACHINE DESIGN, Nov., 1943, Pages 120-123, 234.
2. W. J. Carter—"Acceleration of the Instant Center," *Trans. ASME,* Vol. 72, 1950, Page 142. Discussion by P. G. Jones, *Trans. ASME,* Vol. 72, Page 469.

"Fabrication labor is the most highly skilled in American industry and the hardest to get. If a skilled workman has no work he will naturally go some place else and later, when needed, may not be available for re-employment. Management is aware of the necessity to adjust the defense production in a rapid and orderly fashion to take up the slack in curtailed civilian production in order to avoid competition in the open market with other industries for skilled labor."—ENDICOTT R. LOVELL, *president, Calumet and Hecla Consolidated Copper Co.*

Calculating Speed of Snap-Action Mechanisms

By P. H. Winter
Chief Engineer
Pass and Seymour Inc.
Syracuse, N. Y.

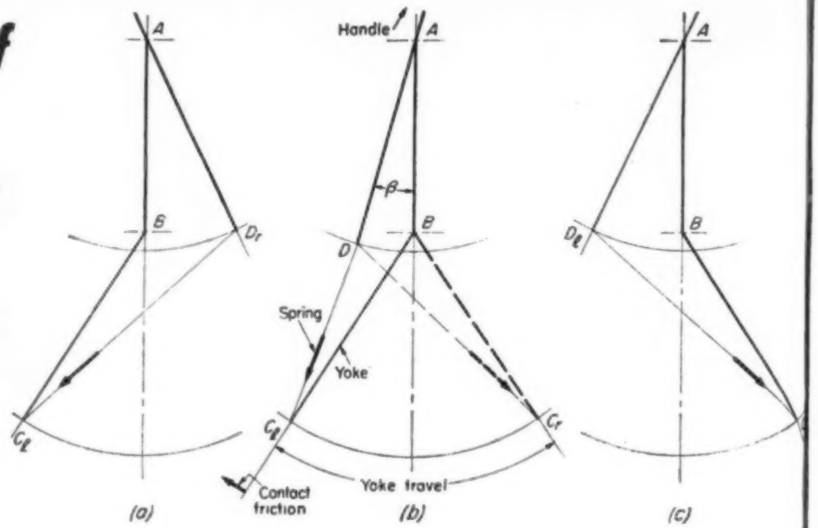


Fig. 1—Diagram of snap-action mechanism, such as employed in switches, showing sequence as yoke and handle move from left-hand limit, *a*, to right-hand, *c*. At *b*, with handle position β, spring force overcomes contact friction and impels yoke to the right

SNAP-ACTION mechanisms find application in electrical circuit breaking devices where their suddenly accelerated motion permits a quick interruption of the current without an unduly large arc. Other uses are found in trigger mechanisms, latching devices and wherever the potential energy of a spring is to be released suddenly.

In the design of snap-action switches where space is at a premium, it is desirable to determine before actually modeling the device whether the spring which can be accommodated will actually produce a fast enough travel to interrupt the arc. Critical velocities are known from previously built designs and being able to calculate the velocities of the moving parts in a new design eliminates a great deal of experimental work.

Although the method described in this article was developed for snap-action switches, it is applicable in principle to other mechanisms.

The particular mechanism to be discused in detail is diagrammed in *Fig.* 1. The first step is to determine the loading rate of the spring in pounds per inch deflection. Next it is necessary to determine the force which must be overcome before the mechanism can start to move. In this example, a retaining force is built into the mechanism in the form of the grip of movable contact blades on stationary contacts. Either calculation or a simple model may be used to determine this force. Where the spring operates at a large radius from the center of rotation as compared with the bearing radius, friction at the bearing may be neglected.

Since the external actuating member, the handle, moves slowly compared with the snap-acting member, the yoke, it is permissible to assume that the full motion of the yoke occurs while the handle remains in one position, *Fig.* 1*b*. Therefore, that position of the external member which produces enough spring pressure to overcome the retaining force must be determined. A graphical procedure is usually adequate. When this position is known, the torque on the moving part at several points in its travel can be determined.

Once torque is known at several points, acceleration of the member can be calculated at the same points with the fundamental expression

$$\alpha = \frac{T}{I} \qquad (1)$$

where α = angular acceleration, T = torque, and I = moment of inertia. Moment of inertia of the entire assembly can be determined analytically, or experimentally if a sample is available, by any of several procedures.

From a plot of angular acceleration versus angular position, graphical differentiation can be performed to obtain velocity at any point. From kinematics

$$\omega = \sqrt{\omega_0^2 + 2\int_{\theta_0}^{\theta} \alpha \, d\theta} \qquad (2)$$

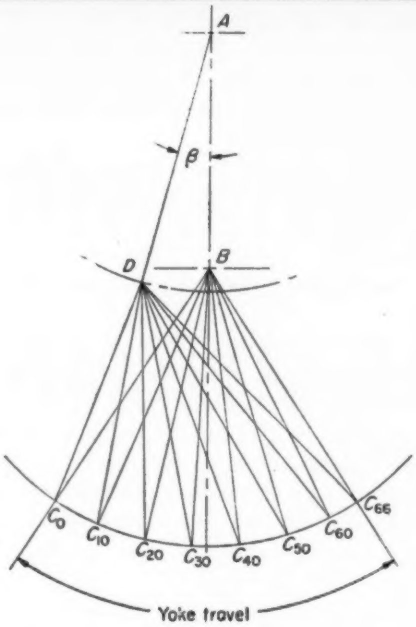


Fig. 2 — Graphical construction for obtaining spring data required for calculation of driving torque

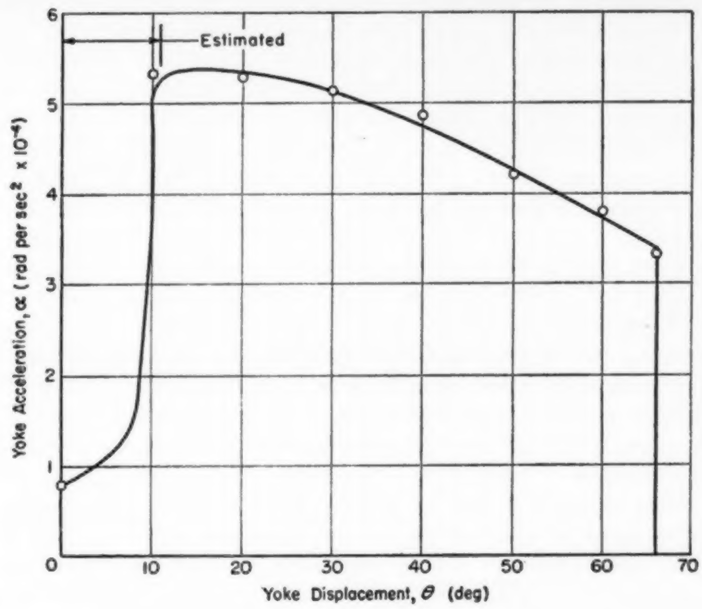


Fig. 3—Acceleration versus displacement of yoke. Successive increments of area under the curve are used in calculation of yoke velocity

where ω_0 = initial velocity, ω = final velocity, θ_0 = initial position, and θ = final position. Area under the acceleration-positon curve is the integral term and can be measured graphically. Dividing the graph into strips permits determination of velocity at a number of positions.

Again by plotting angular velocity against angular position the time for travel may be determined by dividing the graph into strips parallel to the velocity axis. If the average velocity in one of these strips is ω_a degrees per second and the length of the strip = θ_s degrees, then time to travel this distance is

$$t = \frac{\theta_s}{\omega_a} \quad \text{(3)}$$

and the total time to travel the complete distance is

$$t_t = \sum_{\theta_0}^{\theta_f} \frac{\theta_s}{\omega_a} \quad \text{(4)}$$

Hence, the velocity, acceleration and position at any time during the travel of the snap-acting member are known.

To illustrate this method, calculations have been carried through for a mechanism of the type shown

Table 1—Calculation Stages for Obtaining Time Increments

Yoke Position (deg)	Spring Length (in.)	Spring Deflection (in.)	Spring Force (lb)	Angle DCB	Force × sin DCB	Torque lb-ft	Acceleration rad per sec²	Velocity deg per sec	Time sec
0	0.242	0.289	5.40	11½	1.05	0.0301	8,000	0	
									0.00539
10	0.256	0.275	5.15	13	1.16	0.0332	53,400	3,710	
									0.00163
20	0.270	0.261	4.88	14	1.16	0.0332	53,400	8,600	
									0.00098
30	0.285	0.246	4.60	14	1.11	0.0318	51,200	11,700	
									0.00078
40	0.300	0.231	4.32	14	1.05	0.0301	48,500	13,900	
									0.00070
50	0.312	0.219	4.10	13	0.92	0.0264	42,500	15,600	
									0.00065
60	0.328	0.203	3.80	12½	0.82	0.0235	37,800	17,100	
									0.00035
66	0.335	0.196	3.66	11½	0.73	0.0209	33,600	17,800	

in *Fig.* 1 which represents an electrical switch.

The spring has a free length of 0.531-inch; its rate is 18.7 lb per inch deflection. Also from previous designs it is known that a force of 0.75 lb is required to overcome the contact friction. Since BC, the distance from the center of rotation of the yoke to the spring seat on the yoke, is 0.344-inch and the retaining friction acts at a radius of 0.473-inch from B, the retention of 0.75 lb is equivalent to (0.473/0.344) (0.75) = 1.03 lb at C.

The next step is to determine in what position of the handle the spring pressure has a component of 1.03 lb normal to the yoke. This is most easily determined by the construction shown in *Fig.* 2. As a first approximation, the angle β is assumed equal to 10 degrees. For this handle position the length of the spring $= C_0D =$ 0.250-inch by measurement or the spring deflection = 0.281-inch. Therefore, the spring force along the spring axis = 0.281 (18.7) = 5.25 lb. Also by measurement angle $DC_0B =$ 6 degrees. Therefore, the component of the spring force tending to rotate the yoke = 5.25 sin 6 degrees = 0.55 lb, which is not enough to overcome the contact friction.

This construction is repeated for a handle position of $\beta =$ 15 degrees. The spring force is 5.40 lb and the angle $DC_0B = 11\frac{1}{2}$ degrees. The turning component is 5.40 sin $11\frac{1}{2}$ degrees = 1.05 lb. Thus it can be assumed that the yoke will start moving when $\beta =$ 15 degrees.

Now the total angular yoke travel, which in this example is 66 degrees, is divided into an arbitrary number of segments. Numerical subscripts of C in *Fig.* 2 denote angular position from the starting point in degrees. Corresponding spring lengths DC_{10}, DC_{20}, etc., are drawn and for each position, the angles $DC_{10}B$, $DC_{20}B$, etc., are measured. By standard methods, the moment of inertia I of the rotating assembly is found to be 6.2×10^{-7} ft-lb^4.

With the foregoing information, including Equation 1, necessary measurements and computations can be made to accumulate all data up to and including acceleration in Table 1. Actually, however, a modified acceleration factor is required in this case for the 0-degree position.

Since the yoke does not swing freely as soon as it starts moving, but drags the moving contacts over the stationary contacts for about the first 10 degrees of travel, this retention must be allowed for in the torque value. Experience has shown that for this type of mechanism 1/6 of the torque exerted by the spring is available for acceleration. Therefore the 0.0301 lb-ft torque at the 0-degree yoke position is taken as 0.005 lb-ft.

From the tabulated acceleration values in Table 1, the curve shown in *Fig.* 3 is plotted. Between 0 and 10 degrees, the shape of the curve is assumed to be irregular because of the impossibility to exactly allow for the effect of retention.

By use of Equation 2 and the graph, *Fig.* 3, angular velocity for successive positons may be calculated as follows: For yoke position $\theta =$ 10 degrees, $\omega_0 = 0$, $\alpha_0 = 0.8$, and for convenience in calculating the area under the curve, α_{10} is assumed to equal 1.6. Then

$$\omega_{10} = \sqrt{0 + 2\left(\frac{0.8 + 1.6}{2}\right)(10^4)\left(\frac{\pi}{180}\right)(10)}$$

$$= \sqrt{0 + (0.8 + 1.6)(10^4)(0.175)}$$

$$= 65 \text{ rad per sec}$$

$$= 3710 \text{ deg per sec}$$

Similarly, for $\theta =$ 20 degrees, $\omega_{10} = 65$, α_{10} and $\alpha_{20} = 5.3$ from Table 1. Then

$$\omega_{20} = \sqrt{65^2 + (5.3 + 5.3)(10^4)(0.175)}$$

$$= 150 \text{ rad per sec}$$

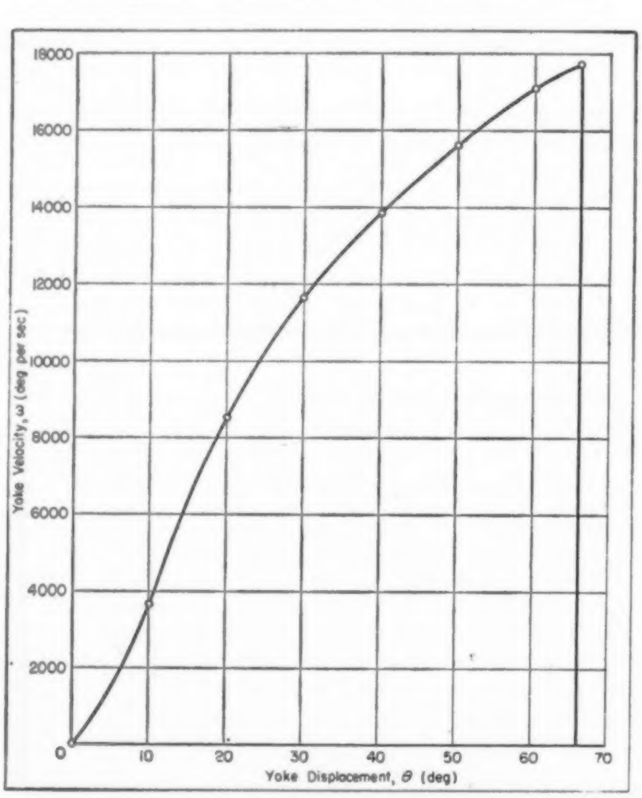
$$= 8600 \text{ deg per sec}$$

This process is continued in 10-degree (0.175-radian) increments to 60 degrees, and a 6-degree (0.105-radian) increment for the last part of the travel. The calculated velocities are shown in Table 1.

Next, these velocities are plotted against the yoke position, *Fig.* 4. Then by use of Equation 3 the travel time can be obtained from this curve graphically. For example, between $\theta = 0$, and $\theta = 10$, $t = (10)(2)/(0 + 3710) = 0.00539$ sec. Between $\theta = 10$ and $\theta = 20$, $t = 20/(3710 + 8600) = 0.00163$ sec. Periods for all positions of the travel are entered in Table 1. Total time, simply the summation of the individual periods, is 0.0105 sec.

The periods can be readily checked with an oscillograph after the device has been built. It has been found that the calculated results agree closely enough with actual test to confirm the validity of this method.

Fig. 4—Velocity versus displacement of yoke. Velocity averages for successive displacement increments permit calculation of time increments



Nomograms Simplify Analysis of Servomechanisms

By R. Hadekel
Consulting Engineer
London, England

SERVOMECHANISMS have become increasingly familiar in recent years. A typical example is the power operation of aircraft controls. Movements imparted by the pilot to the control wheel or rudder pedal are accurately reproduced at the control surface (aileron, rudder, or elevator) while the force which he exerts is amplified, possibly to a substantial extent. The movement at the control wheel or pedal is termed *input,* that at the control surface *output.* The servo functions by measuring the difference between input and output, which is termed *error,* and using a source of power to move the output until the error is reduced to zero, or at least to a sufficiently small quantity. All servomechanisms are based on this principle, although the input and output quantities need not necessarily be displacements of some machine member. They can be velocities, temperatures, pressures, etc.

The essentials of an elementary servo are shown in the block diagram of *Fig.* 1. The output θ_o is brought by the feedback path to the differential *D,* which subtracts it from the input θ_i, the output of the differential being the error ϵ. Blocks *A, B,* and *C* represent a chain of components in the power amplifying system, the output of each forming the input to the next; thus x_1 is the output of *A* and the input of *B.*

These components may be electronic, hydraulic, or mechanical amplifiers, motors, or *passive networks* the purpose of which is to modify the characteristics of the system in any desired manner. For example, *A* may be an ideal amplifier (that is, strictly proportional and devoid of time lag). Then $x_1 = k_1\epsilon$, where k_1 is the amplification ratio. If for the sake of argument *B* is a variable-speed gear, of which x_1 represents the setting (the gear ratio) and x_2 the output displacement (*not* speed), there can be written: $dx_2/dt = k_2x_1$, where k_2 is a fixed constant.

If the system is electrical, *C* might be a motor and x_2 its field current, which produces a torque k_3x_2, where k_3 is another constant, θ_o being the angle moved by the motor shaft. The motor might be used to wind up a spring of elastic rate λ, the armature having an inertia *I* and being subject to a damping force proportional to its velocity, with damping coefficient

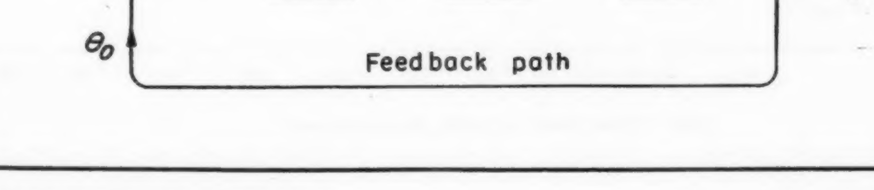


Fig. 1—Block diagram of typical servo system

Data Sheet

μ. Then its equation of motion is

$$k_3 x_2 = I \frac{d^2\theta_o}{dt^2} + \mu \frac{d\theta_o}{dt} + \lambda\, \theta_o$$

Stability and Harmonic Analysis: To insure that a servomechanism is satisfactory it must be established that

1. It is stable in the absolute sense; that is, free from divergent oscillations or nonoscillatory divergence
2. Any oscillations which do occur, and they are most often inevitable, are adequately damped.

In simple cases a direct check on both conditions may be obtained by solving the system differential equation such as the foregoing. In most practical cases the first condition can be checked more rapidly by using the Routh-Hurwitz or Nyquist criteria, which are beyond the scope of this article. However, the Nyquist criterion is based on the determination of harmonic response, which is also the usual approach to a check on the second condition.

On the basis of experience with and analysis of actual servo systems, the following criterion has been evolved, and is the most generally used check on the second condition:

> A servo system is adequately damped if, when the input is a sinusoidal function of time, the ratio of amplitude of output to amplitude of input never exceeds 1.3 (approximately) over the whole range of frequencies from zero to infinity.

Use of this criterion involves the determination of the amplitude ratio at all frequencies, when the amplitude of input varies sinusoidally with time.

Nomenclature and equations leading to analysis for the two foregoing conditions are as follows (*Fig.* 1):

θ_i = Input

θ_o = Output

ε = Error = $\theta_i - \theta_o$

$\frac{\theta_o}{\varepsilon}$ = Loop transfer function = $Ae^{j\phi}$

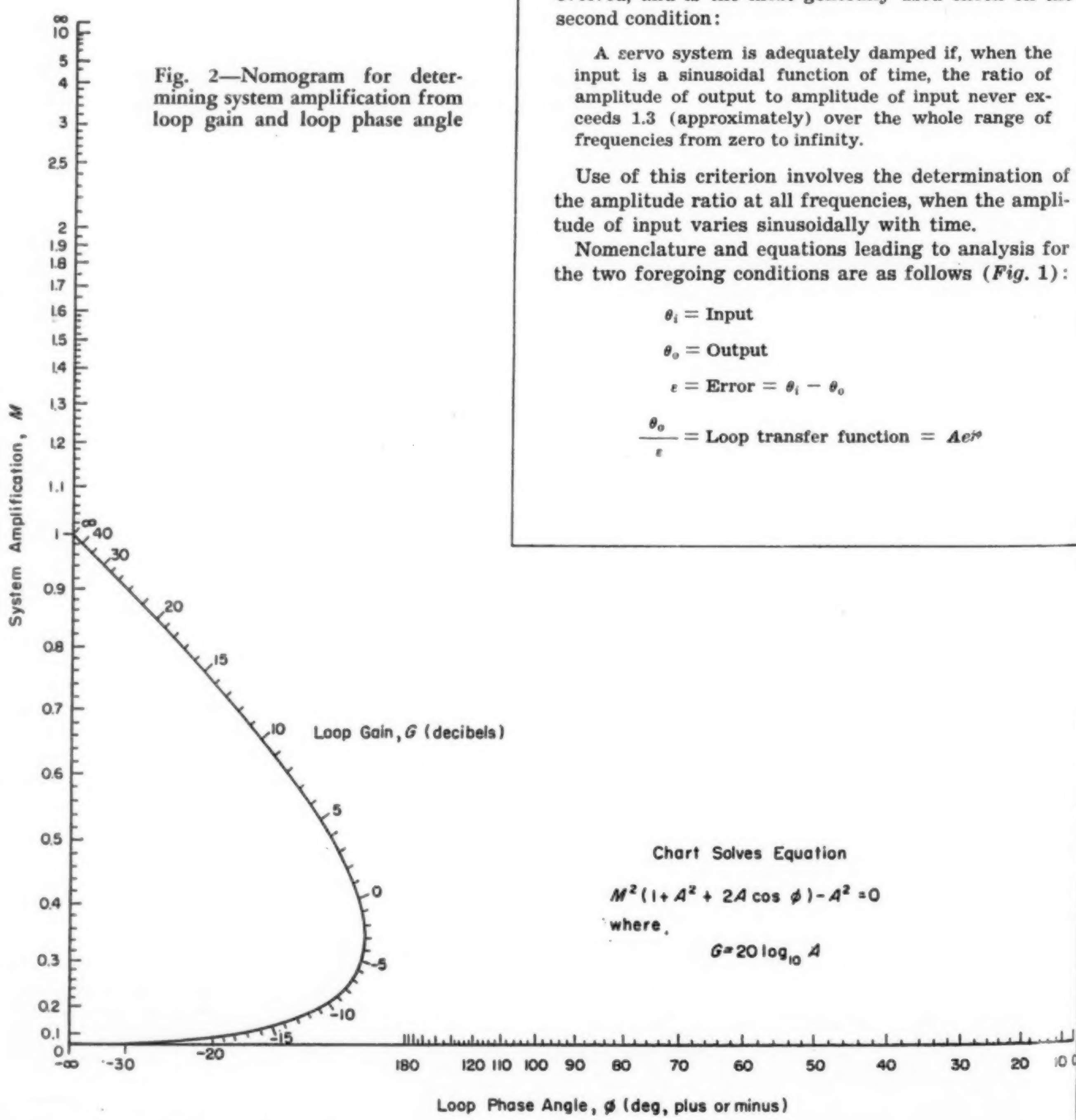


Fig. 2—Nomogram for determining system amplification from loop gain and loop phase angle

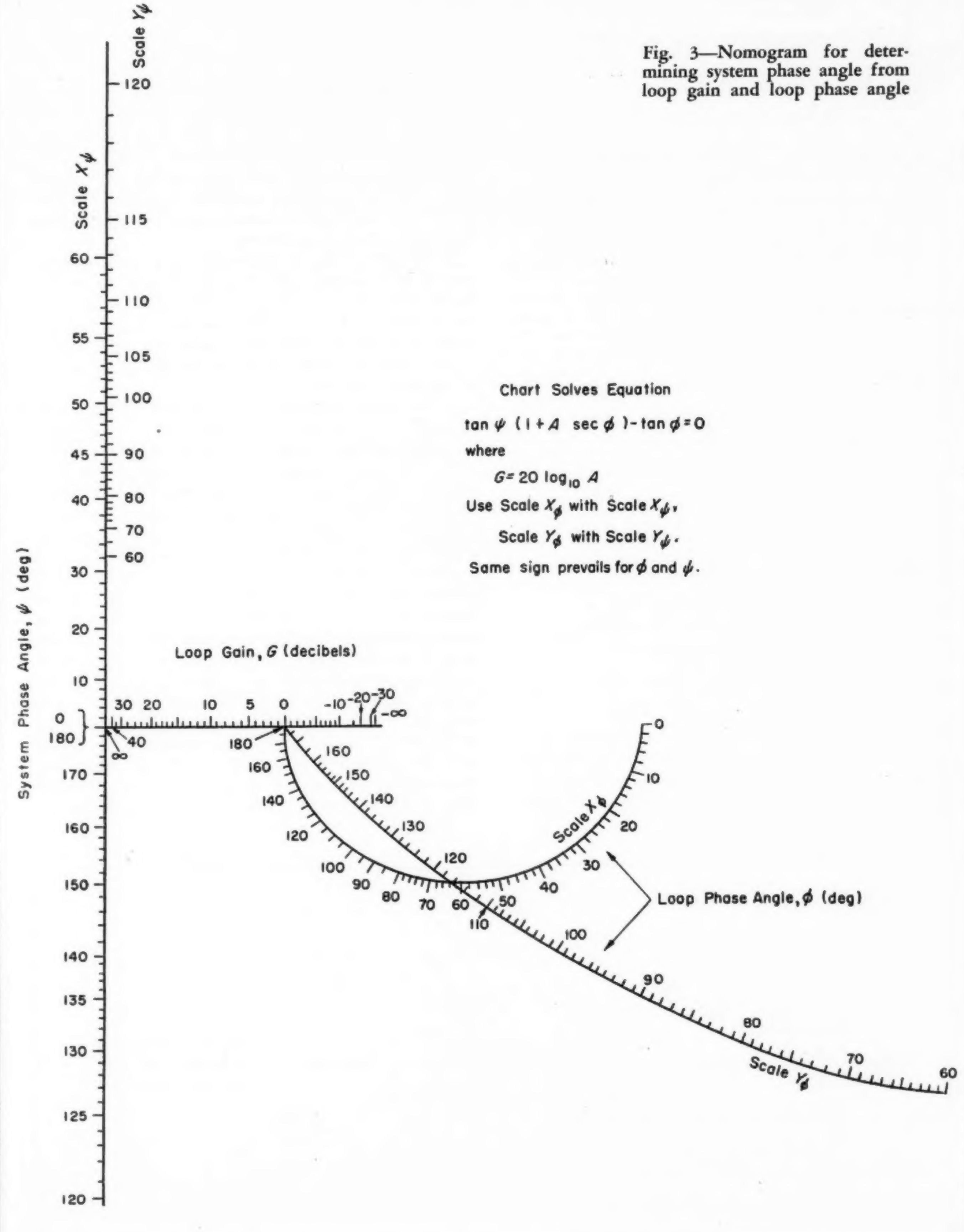


Fig. 3—Nomogram for determining system phase angle from loop gain and loop phase angle

Data Sheet

A = Loop amplification

ϕ = Loop phase angle

$\frac{\theta_o}{\theta_i}$ = System transfer function = $Me^{j\psi}$

M = System amplification

ψ = System phase angle

In the foregoing, $e = 2.71828$, the base of natural logarithms, and $j = \sqrt{-1}$. Since $\theta_i = \epsilon + \theta_o$

$$\frac{\theta_o}{\theta_i} = \frac{\theta_o}{\epsilon + \theta_o} = \frac{\frac{\theta_o}{\epsilon}}{1 + \frac{\theta_o}{\epsilon}} = \frac{Ae^{j\phi}}{1 + Ae^{j\phi}}$$

But in vectoral representation,

$$e^{j\phi} = \cos\phi + j\sin\phi$$

Therefore,

$$\frac{\theta_o}{\theta_i} = \frac{Ae^{j\phi}}{1 + A\cos\phi + jA\sin\phi}$$

or

$$Me^{j\psi} = \frac{Ae^{j\phi}}{1 + A\cos\phi + jA\sin\phi}$$

Manipulation of this latter expression gives

$$M^2 = \frac{A^2}{1 + A^2 + 2A\cos\phi} \quad (1)$$

$$\tan\psi = \frac{\tan\phi}{1 + A\sec\phi} \quad (2)$$

The aim of existing methods of computation, and of the new method proposed in this article, is to solve Equations 1 and 2 graphically, the charts being calibrated in terms of loop gain G in decibels rather than loop amplification A, since G is usually directly available from logarithmic plots of loop gain. By definition

$$G = 20 \log_{10} A$$

The proposed method consists in the use of two nomograms, *Figs.* 2 and 3, which give M and ψ in terms of G and ϕ. Thus in *Fig.* 2, a line drawn through any pair of values of G and ϕ gives the corresponding value of M at its intersection with the M scale. Similar procedure with *Fig.* 3 gives ψ. In *Fig.* 3 two sets of scales are given for ϕ and ψ, to avoid having the chart go to infinity.

The chart of *Fig.* 2 illustrates in a vivid manner several well known laws of servo theory. The line drawn from $M = \infty$ to $\phi = 180$ deg is tangent to the G curve at $G = 0$. This corresponds to the condition when the Nyquist plot passes through the point $-1,0$. This line thus represents the limit of stability in the absolute sense.

A line drawn through $G = 0$ and $M = 1.3$ passes through $\phi = 135$ deg. The angle, $180 - \phi$, is called the phase margin; to give the required degree of stability, the phase margin at $G = 0$ must be at least 45 deg. This, of course, is a necessary but not always sufficient condition. Drawing a tangent to the G curve from $\phi = 135$ deg shows that for this angle the maximum value of M is 1.4, corresponding to $G = 5$ decibels. If $M = 1.4$ is accepted as tolerable, it is evident that unless ϕ changes rather sharply in the neighborhood of $G = 0$, which is rather unusual, the phase margin at $G = 0$ is a rough criterion of the degree of stability, as expressed by the peak value of M.

A line drawn through $\phi = 180$ deg and $M = 1.3$ crosses the G scale at $G = 12.8$ decibels and $G = -5$ decibels. These represent the nearest points to $-1,0$ at which the Nyquist plot can cross the horizontal axis for satisfactory stability. The corresponding values of G are sometimes referred to as *allowable gain margins*. They correspond respectively to

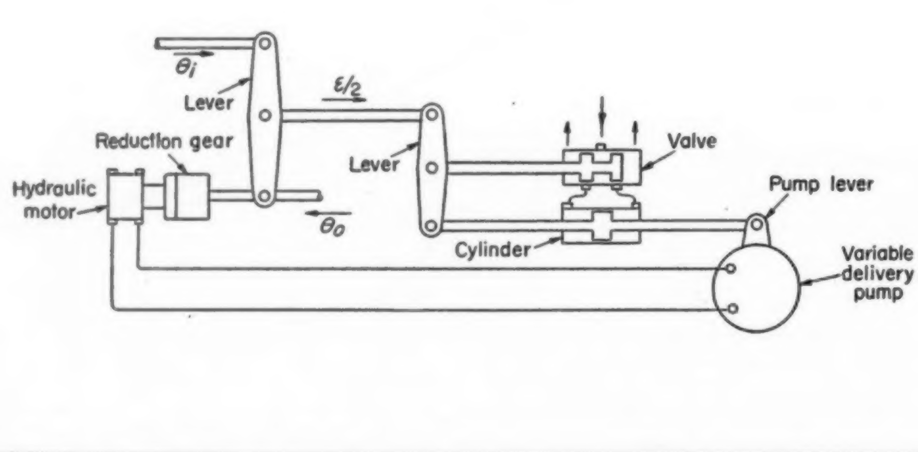


Fig. 4 — Schematic diagram of typical servomechanism

Nyquist diagram points ($A \cos \phi$, $A \sin \phi$) $-4.36,0$ and $-0.565,0$. Thus from Equation 1 the corresponding values of M are $4.36/(4.36-1) = 1.3$, and $0.565/(1-0.565) = 1.3$.

EXAMPLE: *Fig.* 4 shows a frequently used type of hydraulic servo. The input θ_i is applied to the lever, which also receives the output θ_o from a hydraulic motor and reduction gear. The error is applied to a second lever, which also receives the output of a small cylinder, the difference being applied to a valve which actuates a cylinder. Movement of the cylinder is applied to the pump lever which controls the output of a variable delivery pump which supplies a motor.

For a typical servo of this kind, with load due solely to inertia and viscous friction, and neglecting oil compressibility, the loop transfer function is

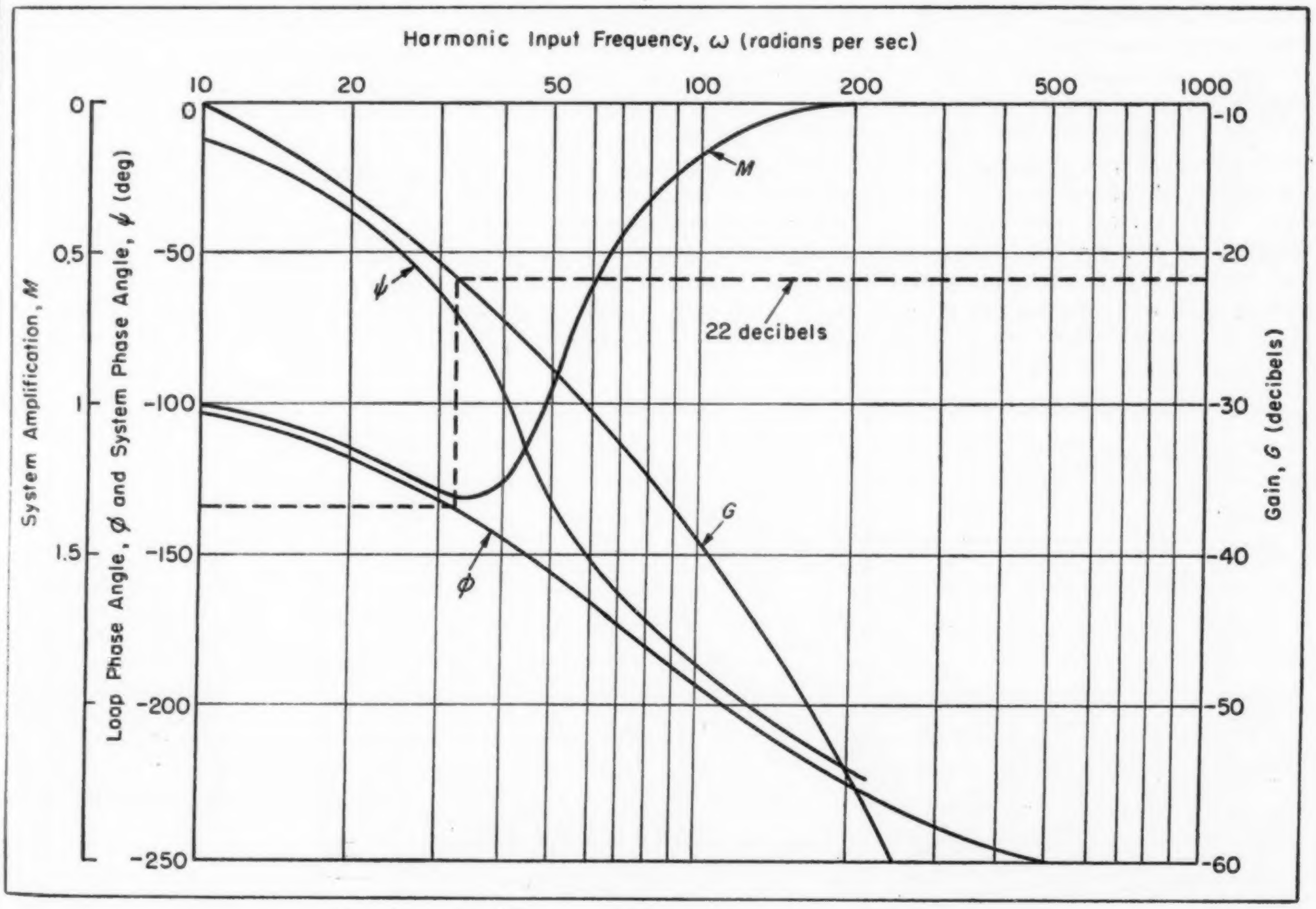
$$\frac{\theta_o}{\varepsilon} = Ae^{j\phi} = \frac{K}{j\omega(1 + 0.008j\omega)(1 + 0.02j\omega)}$$

where K is a constant depending on the length of the pump lever which may be varied to give optimum system performance and $\omega = 2\pi f$, the input frequency or "pulsatance," f being in cycles per second and ω in radians per second.

With K, the gain factor arbitrarily assumed equal to unity for the purpose of initiating the analysis, the foregoing expression can be broken down by standard methods, and values of G, which is a function of A, and ϕ can be plotted against ω, *Fig.* 5. The problem is to determine the permissible value of the gain factor K, and to calculate M for that value, and also ψ. A first guess, which in this instance turns out to be good enough, can be made by applying the phase margin criterion, as follows: Draw a horizontal line for $\phi = 135$ deg, and from the point where this cuts the ϕ curve, draw a vertical line to cut the G curve which it does at an ordinate corresponding to about -22 decibels. The permissible gain factor K is then 22 decibels, $A = 12.5$. Choosing this value, draw a horizontal line (marked 22 decibels in *Fig.* 5) through the ordinate -22 decibels. This line is then the new origin for G, the origin for ϕ remaining unaltered. From these data M and ψ can now be determined by the use of *Figs.* 2 and 3, respectively, and the values thus obtained plotted in *Fig.* 5. The peak value of M is 1.32.

Note from *Fig.* 5 how rapidly M approaches zero at high frequencies, while ψ approaches ϕ. At low frequencies M approaches unity and ψ approaches zero. Near the peak of M, ψ is about 90 deg. These features are characteristic of all servos.

Fig. 5—Curves of harmonic input frequency versus system characteristics for servo diagrammed in *Fig.* 4



Design Abstracts

Automatic Welding Design

. . . for economical production of moderate quantities

By John Mikulak
Worthington Pump and Machinery Corp.
Harrison, N. J.

IN THE past there has been a tendency to reserve so-called automatic or semiautomatic high-production welding machines for large-volume production. However, automatic processes and equipment are now available which require less exacting tolerances on joint fit, plate preparation and base-metal metallurgy, facilitating their application to general product design. With greater ingenuity on the part of the product designer and the tool engineer, universal tooling and methods can be provided to utilize these automatic processes for welding joints of relatively short lengths and of infrequent identical occurrence. Some of the later developments now being applied commercially include low-hydrogen electrodes and fluxes, twin-arc submerged-welding machines, and automatic gaseous shield-arc equipment.

General Design: To provide the performance features required of weldments manufactured for various applications, a wide selection of available design approaches becomes necessary. Care must be taken to satisfy all codes and to incorporate the trade advantages generally supplied by the product. The design must not require fabrication operations which cannot be economically produced by existing equipment in the shop or, where possible, to cost advantage by outside suppliers.

Because of these factors, the economics involved in welded design are, to a great extent, individual problems. However, to obtain best economy, there are several fundamentals that must be adhered to:

1. Materials should be selected for the best possible weldability and should have weld environments which will assure suitable metallurgical and physical joint properties. Alloys should be chosen for minimum prewelding and postwelding operations

2. Structures should be composed

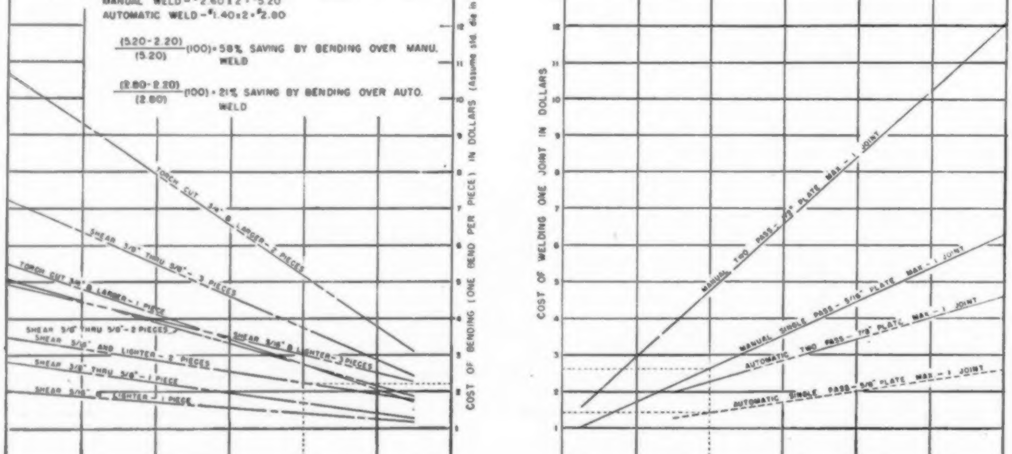


Fig. 1—Cost charts for comparison of bending 90-degree joints with the welding of separate sheets which have been sheared or torch cut. Cost figures are per foot

of as few elements as possible and each element should perform a functional service. Use of pressings, castings, and forgings may provide a composite design having improved cost and performance characteristics

3. Welding should be decreased to a minimum by making use of bending and by specifying joints which require a minimum amount of deposited weld metal

4. All welding should be clearly shown and specified on drawings; weld sizes should be held to a minimum. Tolerances should be shown for fabrication and assembly operations and should be specified to produce optimum conditions at root openings of joints to be welded and to allow for distortion from welding

5. Joints specified should provide for good fit-up with minimum effort in fabrication and assembly

6. Joints should be designed for use of automatic and semiautomatic welding processes. Where manual arc welding is necessary, the joint fit-up should allow for the use of the largest possible electrode. On heavy open-hearth steel structures, underbead cracking can be eliminated by use of a suitable electrode such as the low-hydrogen type

7. Welding should be balanced, as nearly as possible, around the neutral axis of the welded structure to assist in controlling distortion. Joints should be located for minimum grinding and cleaning

8. Design should provide, if possible, that all welding be applied from one side of the structure to reduce the amount of handling. This may require the use of subassemblies with final assembly welding accomplished in a jig

9. Proper assembly and weld procedures should be provided to standardize product quality and cost. These procedures should be such as to obtain maximum benefits from welding jigs and other production equipment.

In addition to these general design considerations, the following factors contribute to shop efficiency and, consequently, production costs:

1. Welding-shop floor should be organized, especially on heavy manual welding and automatic welding, to maintain maximum operator factor. This requires that setup, poor-fit repair and jig-disassembly operations, where possible, should be done by persons other than the welder

2. Universally applied automatic welding equipment and universal jigs should be provided to produce maximum arcing time. Standard automatic welding heads can be modified to provide ample tolerances on joint openings and thus allow for the use of conventional fabricating methods with standard shop equipment

3. Fabricating operations should be accomplished by using gages and tools ordinarily supplied with the equipment. The use of chalk marks, either scaled off on the piece or traced from a template, as guide lines for shears and bends can prove costly, especially in the setup and welding operations.

Design Application: For general fabrication as opposed to mass production it is necesary to consider relatively small quantities and frequent jig setup operations. The initial task in design is to provide an arbitrary set of standards and later to correlate the actual designs to correspond. This approach will provide interchangeable parts or subassemblies on the various sizes of manufactured products which in turn will result in a large number of identical or similar shop operations. As a result improved economy will be obtained in material purchasing, material and parts storage and handling, inventory turnover, and production operation. Further, greater simplicity will be realized in the construction of universal jigs to accommodate a partial or complete group of various size units.

A general design approach to cover fabrication and assembly needs can be established from a survey of all parts being produced. In making this survey consideration should be given to:

1. Production of component parts using general-purpose jigs

2. Fabrication of components by pressing, bending, shearing or torch cutting

3. Utilization of parts made by casting and forging as elements of

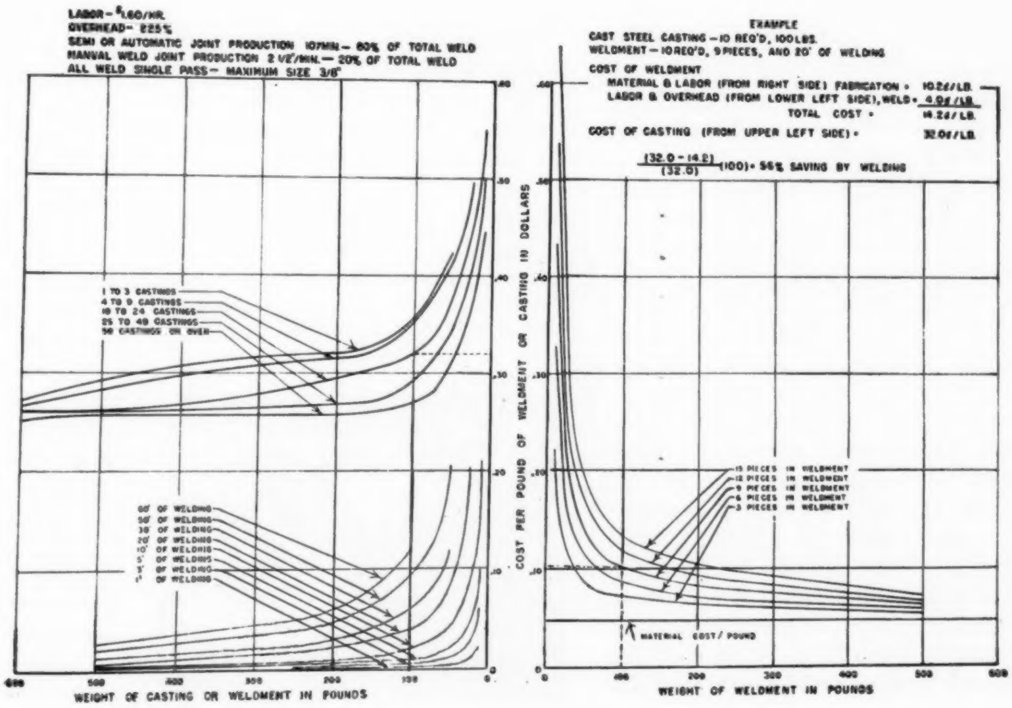


Fig. 2—Cost charts for comparison of low-carbon steel castings with weldments. Total cost of weldments is obtained by adding costs from right hand chart to those in left hand chart

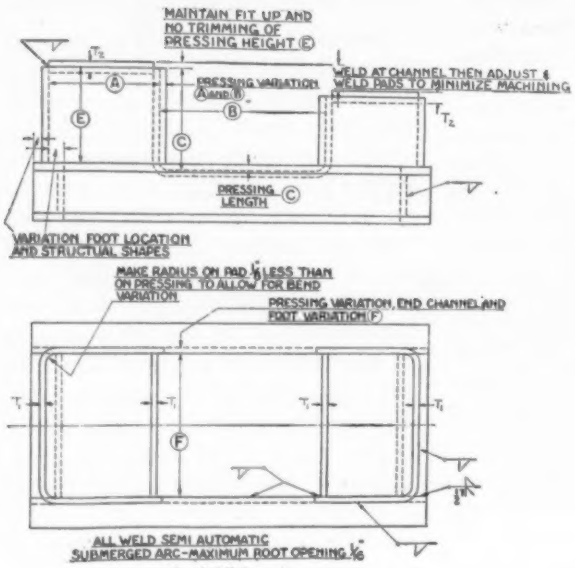


Fig. 3 — Bedplate design for economical automatic welding. Maximum fit-up tolerances decrease the finishing operations to a minimum

the weldment

4. Standardization of material analysis and of plate, bar and shape sizes.

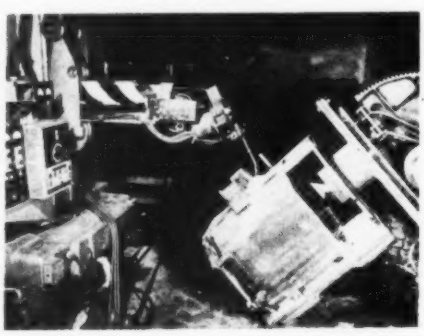
The data obtained from the survey should be compiled in chart or graph form for quick reference. As a supplement to this data, charts should be made up which allow costs for bending of sheets of various thicknesses, lengths, and quantities to be compared to costs of shearing or torch cutting separate plates and welding them together. A chart of this type is illustrated in *Fig.* 1; pressing costs are shown on the left and manual and automatic welding costs are on the right. In both instances, cost figures cover fabrication, setup and handling of material for making the parts suitable for final operations in bending and welding. Also included in the welding costs are cleaning operations for removing flux and spatter. Material cost has been assumed identical for both.

The definite effect of automatic welding on cost economy in a weldment is illustrated clearly in *Fig.* 1. However, these figures are for a small number of pieces. As the number of identical pieces increases, the cost rate favors bending. In the chart showing bending cost, time has been allowed for adjusting dies, for ram travel and for stop gages, but not for changing dies. Allowance for the last factor has been left out because a standard die set will perform satisfactorily for a large number of different jobs in right-angle bending.

Another valuable design chart is shown in *Fig.* 2. Approximate cost per pound of simple low-carbon steel castings and properly designed weldments of the same weight produced from open-hearth steel are compared. The casting costs, upper left-hand side, allow for weight classification and casting quantities but do not allow for original pattern cost. To find the cost of the weldment, material and fabrication costs must be obtained from the right-hand chart and added to the costs shown in the lower left-hand side. The weldment costs on the left assume 80 per cent of the welding is done by either an automatic or semiautomatic submerged-arc welding process and the remaining 20 per cent is accomplished manually.

The chart in *Fig.* 2 also shows the cost effect of increasing the number of pieces used in a weldment. A complete analysis should also include similar charts showing costs for ordinary gray cast iron, ductile cast iron, and riveted construction versus welding.

Fig. 4 — Automatic welding-head manipulator and universal positioner for use on moderate quantity production. Longitudinal, transverse, and circular welds can be made with this equipment



It is important to note, *Fig.* 2, that as a weldment decreases in weight, the cost per piece, computed on a pound basis, increases more rapidly than it does with castings. Also, as the number of pieces in a weldment increases, cost increases at a greater rate, emphasizing the importance of carefully investigating the possible use of castings, pressings, or forgings for component parts.

For fabricating rectangular or other straight-sided plates, shearing is recommeded for thicknesses to ⅝-inch. For heavier plates, torch cutting should be used. Shearing on heavy plates causes distortion in transverse and longitudinal directions resulting in poor joint fit-up. When castings or forgings are used, the weld joint preparation, where required, should be incorporated on these parts.

To provide lowest weldment cost, design should allow maximum shop opportunity to adjust dimensions before welding parts which have controlling surfaces. These parts should be adjusted after the major portion of the welding at the control area has been completed. In this way straightening and machining cost can be kept to a minimum. Further, design should also allow for maximum possible fit-up tolerance on all parts. A bedplate design consisting of a channel frame and two pedestals is shown in *Fig.* 3. Here such adjustment has been allowed for maintaining tolerances on fabrication and welding with only a minimum of trimming, fitting, straightening, and machining labor. A minimum number of plate thicknesses has been specified, thus reducing the amount of handling.

All welding, *Fig.* 3, is accomplished from the outer side of the weldment and, by using a welding positioner, all welds can be easily reached with minimum effort and time. This assembly can be completely welded by use of the semiautomatic submerged-arc process at welding speeds of 20 to 30 inches per minute and an operating factor of approximately 40 to 50 per cent.

(*Continued on Page* 224)

NEW PARTS

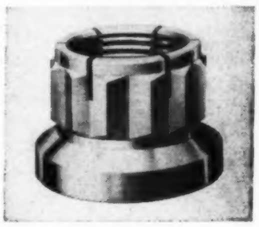
AND MATERIALS

. . . presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 189

EXTERNAL WRENCHING NUT 1

. . . high strength with minimum weight

Standard Pressed Steel Co., Box 102, Jenkintown, Pa.



As an example, the $1\frac{1}{4}$ in. size of this locknut has a minimum tensile strength of 193,700 lb, yet weighs only 0.52-lb.

Size: $\frac{1}{4}$ to $1\frac{1}{2}$ in. in NF thread series.

Service: Thread locking with tensile strength over 160,000 psi; locks securely in any position on threaded member; can be used at temperatures up to 550 F without loss of locking efficiency; large bearing surface; head fits standard box or socket wrenches for use in restricted space.

Design: All-metal, one-piece construction, with spring-steel locking section; 12 point serrations on head.

For more data circle MD 1, Page 189

PLASTIC PUTTY 2

. . . seals wide gaps in metal or glass

Minnesota Mining & Mfg. Co., Adhesives & Coatings Div., 411 Piquette Ave., Detroit 2, Mich.

Wide seams, gaps and holes can be filled to provide a weather and watertight seal.

Designation: EC-1167.

Form: Soft putty; weight 12.9 lb per gal.

Service: Sealing pinchweld openings, bolts and washers, molding, clip openings, autobody seams and joints, firewall openings, and for capping holes; continuous service to 200 F, but will not sag or flow up to 300 F; remains flexible to −10 F; permanently soft and pliable; nonshrinking; not sticky to touch; resists water and weathering; will not stain or discolor paint; applied by putty knife or screw-type or high-pressure extruding equipment.

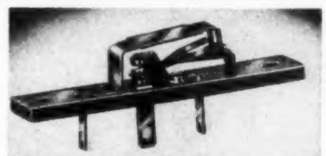
Properties: Synthetic resin with 100% solids content; adheres to steel, aluminum, glass and many other nonporous surfaces; grayish-beige color; viscosity, 8 mm with ASTM Penetrometer test at 80 F with 150 gm added weight.

For more data circle MD 2, Page 189

SNAP-ACTION SWITCH 3

. . . fits in limited installation space

W. L. Maxson Corp., Unimax Switch Div., 460 W. 34th St., New York 1, N. Y.



Designed for low-cost applications, this switch gives the same precision control as larger enclosed switches.

Designation: Type E.

Size: $1\frac{1}{4}$-in. long, $\frac{5}{16}$-in. wide, $\frac{3}{8}$-in. high.

Service: Resistive loads of 10 amp at 125 v ac and 5 amp at 250 v ac; close movement differential, requiring only few ounces actuating force; contacts have positive wiping action.

Design: Snap action; open blade; single-pole, double-throw; normally-open or closed; terminals are integral with contact supports, with lower series resistance and less heating.

For more data circle MD 3, Page 189

MOTOR ALTERNATOR 4

. . . supplies 400-cycle current

American Electric Motors, 4811 Telegraph Rd., Los Angeles 22, Calif.

Using no rotating coils, brushes or springs, this power supply is small and unusually compact.

Size: 22-in. long, 12-in. wide, 12-in. high; weight 125 lb.

Service: Supplying 400-cycle current; output, 1000 w at 115 v single-phase or 1800 w at 115/200 v 3-phase; meets requirements of AN-E-19 for power supplies; voltage regulation, ±1%; pure wave form with less than 5% total harmonic content.

Design: Alternator is driven by integral single or 3-phase motor on common shaft; laminated rotor, mounted on ball bearings, is only moving part; shape of inductor and skew of inductor laminations gives a pure wave form.

For more data circle MD 4, Page 189

NEW PARTS AND MATERIALS

THREAD-CUTTING SCREWS 5

. . . eliminate reaming on clogged holes

Shakeproof Inc. Div., Illinois Tool Works, St. Charles Rd., Elgin, Ill.

Developed for final assembly of porcelain-enameled parts, this thread-cutting screw reams out clogged holes.

Size: To specifications; presently manufactured sizes range from 6-32 x ½-in. to 10-24 x ¾-in.

Service: Fastening sheet-metal parts; reamer point scrapes hole clean and allows thread-cutting action to follow, eliminating a separate reaming operation.

Design: Self-tapping screw with 4-sided reaming point; available in variety of head styles.

Application: Stoves, refrigerators, washers.

For more data circle MD 5, Page 189

RUBBER-PHENOLIC VARNISH 7

. . . makes high-impact-strength laminates

General Electric Co., Chemical Dept., Pittsfield, Mass.

Plastic laminates manufactured with this varnish are claimed to have higher impact strength, more flexibility and toughness than conventional mechanical grades.

Designation: 12359.

Form: Liquid with 40% solids content.

Service: Paper and fabric plastic laminating for high impact strength, flexibility and toughness; impact strength is 1.4 to 1.73 lb per in. notch for NEMA X grade, 4.5 to 5.0 lb per in. notch for NEMA C; pressing cycle is comparable to other phenolics; solvent, methyethylketone.

Properties: Rubber-modified phenolic varnish; specific gravity, 0.93; viscosity (25 C), 700-1000 centipoise.

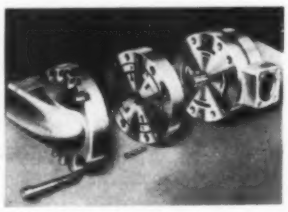
Application: Laminates for gears, spools, pulleys, shuttles.

For more data circle MD 7, Page 189

HYDRAULIC PUMP-MOTOR 6

. . . vane-type for 2000 psi pressure

Denison Engineering Co., 1160 *Dublin Rd., Columbus* 16, *O.*



Without alteration this unit may be used as either a pump or motor.

Designation: TMB, TMC, TME, TMG.

Size and Service: For maximum oil pressure of 2000 psi; no alterations necessary to change from pump to fluid motor; hydraulically balanced; pump characteristics as follows:

Model	Size (in., approx)	Delivery (gpm)	Input (hp, for 2000 psi)
TMB	4⅛ square, 8½ long	2.7-7.5	5.3-10.9
TMC	5⅞ diam, 9⅝ long	5.0-17.0	9.0-22.4
TME	11¼ diam, 15 long	20.0-46.0	29.4-59.0
TMG	11¼ diam, 16 9/16 long	50.0-77.0	74.5-103.0

motor characteristics as follows:

Model	Speed (rpm, max)	Displacement (in.³ per rev.)	Torque (lb-in. per 100 psi)	Output (hp per 100 rpm)
TMB	2000	0.8-1.2	13.0-18.0	0.41-0.58
TMC	2000	1.5-2.3	23.5-37.1	0.75-1.17
TME	1800	5.5-9.7	88.0-154.6	2.79-4.88
TMG	1200	12.0-16.1	191.3-257.0	6.06-8.14

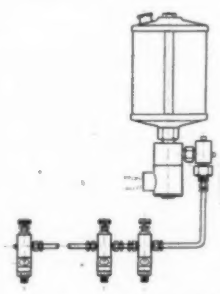
Design: Constant-displacement, single-stage vane-type; direction of rotation can be reversed by change in position of center cartridge; range of capacities provided by use of interchangeable cam rings; vanes have dual sealing edges for better valving action at exhaust; ports can be on same side or opposed.

For more data circle MD 6, Page 189

GRAVITY OILING SYSTEM 8

. . . with solenoid-operated shut-off valve

Oil-Rite Corp., 2376 *Waldo Blvd., Manitowoc, Wis.*



Designed for applications where lubrication points are far apart, this system operates only when the machine is running.

Designation: Electro-Oiling system DEI.

Size: Reservoir and solenoid valve have ¾-16 threaded shank for mounting; ¼-in. OD tubing; reservoir capacity and size as follows:

Capacity	OD (in.)	Height (in.)	Capacity	OD (in.)	Height (in.)
9 oz	3	3	½-gal	5	7
1 pt	3½	4	1-gal	5	12
1 qt	4¼	5			

Service: Gravity feed of oil to as many as 24 bearings; oil is fed to bearings only when machine is operating; bearings can be spaced far apart; feed valves can be individually or gang mounted; solenoid valve is approved by Underwriters Laboratories.

Design: Oil is released from a reservoir mounted above highest angle sight feed valve by a solenoid shut-off valve; feed valves, connected in series so that oil flows from one to the other, can be individually regulated for proper drop feeding; oilers have aluminum-alloy bodies and Lucite reservoir, or glass for temperatures above 160 F; solenoids can be furnished for all commercial voltages, ac or dc.

For more data circle MD 8, Page 189

SLEEVE BEARING DATA

Bearing DESIGN

SLEEVE BEARING DATA

Corrosion of Bearings-2

RESISTANCE to corrosion is a factor that merits careful consideration in selecting the type of bearing to be used. This includes the period prior to installation or storage and after installation. In this treatise we will limit the discussion to the latter.

Under service conditions, temperature and the corroding medium are the controlling factors. Bearings are used in various media but these are too numerous to discuss in general terms. The usual medium is oil so it should be given first consideration.

It is difficult to know exactly what role corrosion plays under operating conditions since all that can be observed is the rate of disappearance of the bearing surface. This rate of disappearance depends on wear plus corrosion. However, from experience and laboratory corrosion tests a guide is available.

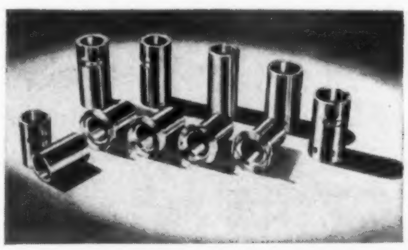
At temperatures above 200° F., and in the presence of some air, corrosion in the presence of oil may be expected. The air will oxidize the oil and acid products will be formed that are definitely corrosive to many metals. However, it is not the actual corrosion we are interested in but rather the corrosion *rate*. If the corrosion rate is one-tenth the wear rate, then it is negligible but if it is equal to or greater than the rate of disappearance due to mechanical wear then it is appreciable.

The relative corrosion of bearing metals is much different when in operation as compared to exposure such as in storage. Peculiarly, lead is again the major offender but steel is practically non-corrosive. A comparison of the tendency to corrode is approximately as shown in the chart below.

Pure lead will corrode in hot acidic oil at a very rapid rate in terms of bearing life. This rate of corrosion is substantially reduced by two factors. First, if the oil contains natural inhibitors; or if the oils are highly refined to remove the natural inhibitors and additives are used to restore this inhibition. And second, the addition of tin to lead base alloys greatly increases the corrosion resistance.

In the copper-lead alloys the rate of corrosion depends on the amount of lead in the alloy under corrosive conditions since the lead is present in free pockets. The lead cannot be protected with tin as in babbitt since the tin will alloy with the copper rather than with the lead. The only alternatives are to use copper-lead under conditions where severe corrosion is not encountered or to use an overlay of tin-base or lead base alloys over the copper-lead.

Where corrosion is a major factor in determining bearing life and yet the surface properties of a soft metal are required, a tin alloy is recommended.



Cast bronze bearings have long been a favorite with leading builders of out board motors.

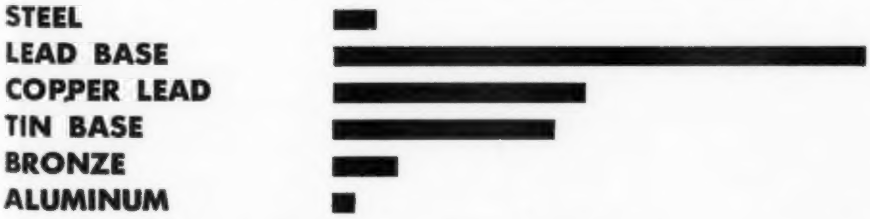
If the properties of a soft metal are required and price is a major factor then lead-base babbitts may be used and corrosion resistance is obtained by the use of tin in the lead alloy. For a straight lead-tin alloy about 6 percent tin is required but in the babbitts where greater strength is required in heavy sections, the tin content may be dropped as low as 1 percent in the presence of antimony and fair corrosion resistance will be obtained.

Aluminum alloy bearings provide excellent resistance to corrosion.

For load applications intermediate to the babbitts and the bronzes, aluminum offers possibilities for excellent corrosion resistance.

Where oil temperatures run under 200° F. corrosion problems are not likely to be encountered unless water is liable to be present from some external source or due to exposure to wet conditions or condensation in outdoor environments. In this case the tin-base babbitts at low loads and the bronzes at high loads are most liable to meet requirements.

Relative Comparison of Corrosion



Tendency of bearing materials to corrode in the presence of hot oil and air.

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

•

This bearing sheet data is but one of a series. You can get the complete set by writing to—

Johnson Bronze

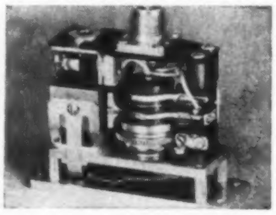
SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.

NEW PARTS

ON-OFF DC TIMER 9

. . . in wide range of timing cycles

Pacific Div., Bendix Aviation Corp., 11600 *Sherman Way, N. Hollywood, Calif.*



Possible applications include sequencing or limiting the operating cycle where safety of equipment requires delays in frequency or duration of operation.

Size: $3\frac{7}{16}$-in. high, $3\frac{13}{16}$-in. wide, 1.44-in. deep; weight 1 lb.

Service: On-off timing with cycle of 20 ± 3 sec for basic unit, which can be modified to give from 3 to 90 sec; gear train modifications can provide cycling up to several min; voltage, 14-30 v dc; max relay current, 5 amp at 28 v dc at 50,000 ft altitude; max motor current, 0.22-amp; max solenoid current, 0.2-amp; ambient temperatures, -70 to $+200$ F.

Design: Closing external switch energizes relay, shunt-wound timing motor, and solenoid which operates the constant-speed clutch; clutch engages a cam which opens all circuits at end of timing cycle; when clutch disengages, cam is reset by a clock-spring mechanism; 6-in. coded leads provided.

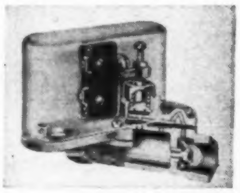
Application: Jet-engine igniters; starters; solenoid valves.

For more data circle MD 9, Page 189

AUTOMATIC INTERLOCK 11

. . . protects fluid lines from flow deviations

Hays Mfg. Co., 820 *West 12th St., Erie, Pa.*



Differential of flow pressure across a nozzle operates the switch.

Designation: Shur-Flo.

Size: ½-in. pipe size, adaptable to other pipe sizes.

Service: Protecting water, air or light-oil circuits from deviations in flow; one type closes switch when pressure falls below a predetermined minimum, the other when supply exceeds given maximum; protective strainer not required; may be connected to control switch or to an alarm signal; unaffected by scale or foreign matter; liberal overtravel on switch; slight time lag for flow surges; installed in any position.

Design: Diaphragm motion, caused by changes in differential pressure across a nozzle, moves plunger and lever arm to make or break switch contacts; predetermined pressure drop (and flow) is determined by choice of nozzle, with minor variations possible by adjusting a screw in the lever arm; bronze body; Buna-N rubber parts.

Application: Condensers, humidifiers, air compressors, welding machines, electric garbage disposal units.

For more data circle MD 11, Page 189

ENGINE GOVERNOR 10

. . . operates over wide range of speeds

Pierce Governor Co. Inc., Box 1000, *Anderson, Ind.*

Correct engine control at any speed setting for all popular industrial and farm engines is provided.

Designation: GC-979.

Size: Basic body size, 3⅝-in. diam, 5½-in. long; governor shaft, 0.624-in. diam, 1½-in. extension; rocker shaft extension, 1½ in. both sides; all dimensions approximate; no allowance for carburetor control lever, bracket, or speed-control lever and stop bracket.

Service: Controlling engines at speeds from 1200 to 2600 rpm; higher speeds obtainable by changing pulley ratio; operating spring and weight are similar in any speed ranges; for variable-speed operation, a quadrant or manual control sets the speed-change lever, which is locked by high and low-speed stop screws for constant-speed operation; mounted on either side of engine.

Design: Centrifugal governor; mounting bracket can be mounted in up, down, right or left positions; speed-control and carburetor-control levers can be mounted on right or left end of rocker shaft, independently of each other; carburetor-control lever can point at any angle from straight up to down.

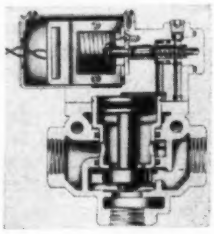
Application: Air compressors, hoists, tractors, arc welders, corn shellers.

For more data circle MD 10, Page 189

MASTER VALVES 12

. . . for solenoid or pilot valve control

Hannifin Corp., 1101 *S. Kilbourn Ave., Chicago* 24, *Ill.*



Interchangeable heads for the basic valve assembly permit several types of operation.

Designation: Pilot-Master; 2 or 3-way—B-1 (remote control), B-2 (solenoid with spring-return pilot head), B-3 (solenoid with pressure-return pilot head); 4-way—BB-1, BB-2 (same as B-1 and -2), BB-4 (solenoid with momentary contact pilot head).

Size: B series for ⅜, ½, ¾, 1 and 1¼ in. IPS; BB series for ⅜, ½, ¾-in. IPS.

Service: Pilot control of air or gas pressure from 15 to 150 psi; higher pressures with water or oil; speeds to 600 cycles per min; corrosion-resistant; remote-control (B-1, BB-1) valves can be used with solenoid, ball-cam, palm-button, hand-toggle (locking and nonlocking), foot (locking and nonlocking), mechanical-toggle, roller-cam or piston-operated remote valves; solenoids for 115, 230 or 460 v, 25 or 50/60 cycles; normally-open or normally-closed by rotating head 180 deg.

Design: 2, 3 or 4-way; removable cartridge contains main piston-poppet valve; internal pressure returns piston-poppet, eliminating main-valve spring; bronze, stainless-steel and oil-resistant synthetic rubber are materials used.

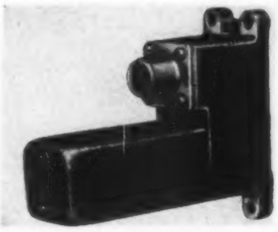
For more data circle MD 12, Page 189

NEW PARTS AND MATERIALS

ROTARY ACTUATOR 13

. . . develops high torque for its size

Pacific Div., Bendix Aviation Corp., 11600 Sherman Way, N. Hollywood, Calif.



Miniature size and light weight is made possible by the development of a new concentric square split-series motor.

Designation: Geneva-Loc series 128.

Size: 4.1-in. long, 1.2-in. wide, 2.1-in. high; weight, 14 oz.

Service: Develops 100 lb-in. torque at 90 deg rotation per sec, other ratings available; for 28 v dc.

Design: Concentric square split-series motor with integral switches in the connector and necessary gear reduction; motor mounting face includes electric connector pins which automatically make contact as motor is assembled to the gear case; motor is available separately for products in which gear reduction and limit switches are already built in.

For more data circle MD 13, Page 189

ALLOY STEEL . 15

. . . for three different service requirements

Carpenter Steel Co., 320 W. Bern St., Reading, Pa.

This triple-duty boron steel is suitable for hard-tempered, tough-tempered or mild-tempered steel parts.

Designation: 5-876.

Form: Billets or bars annealed or treated to test, wire or strip.

Service: Three types of duty—(1) for hard-tempered parts such as gears, racks, clutch pins and locking pins, with high surface hardness of Rockwell 50 C to 56 C, wear resistance, good strength, and toughness—(2) for tough-tempered parts such as shafts, axles, bolts, and studs, with high strength of 115,000 to 235,000 psi tensile, toughness, and moderate hardness of Rockwell 31 C to 49 C, brinell 286 to 477—(3) mild-tempered alloy steel, readily machineable, with tensile strength of 135,000 psi, hardness of brinell 275.

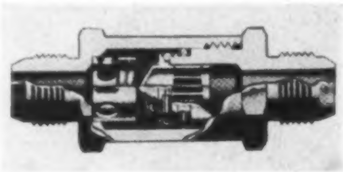
Properties: Cold-melt, grain-controlled, electric-furnace steel with analysis of C 0.5, Mn 0.87, Si 0.25, Cr 0.7, Ni 0.55, Mo 0.1, V 0.17, boron added; drawn between 400 and 550 F for (1), 700 to 1200 F for (2); supplied as noted for (3).

For more data circle MD 15, Page 189

CHECK VALVE 14

. . . for high-pressure air or nitrogen

James-Pond-Clark, 1247 E. Green St., Pasadena, Calif.



Unlike conventional check valves, this valve protects the pneumatic system even when small leaks in the system set up a slight pressure differential.

Designation: 299A-4TT.

Size: Hex, ¾-in.; length conforms to AN 6249-4; weight, approximately 1 oz; lightweight version, special.

Service: Protecting compressed air or nitrogen systems from 0 to 3000 psi; dead-tight sealing at both high pressures and very low pressure differentials; proof pressure, 6000 psi; burst pressure, over 7500 psi; operating temperature −65 F to +165 F.

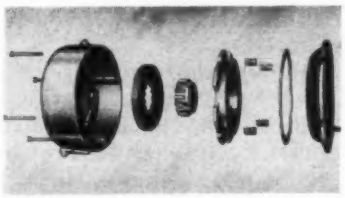
Design: Spring check valve with special O-rings in sizes conforming to AN 6227 specification but molded of AN 6290 compound; AN 6290 compound has Durometer hardness of 90, is more wear-resistant than softer AN 6227 compound; aluminum valve body.

For more data circle MD 14, Page 189

MAGNETIC BRAKE 16

. . . permits use of both ends of motor shaft

Reuland Electric Co., 2001 W. Mission Rd., Alhambra, Calif.



New "doughnut" solenoid design eliminates the conventional "dead end".

Size: $8\frac{3}{16}$-in. diam; 3 in. wide for 3, 10 or 15 lb-ft ratings, 4 in. for 25 and 35 lb-ft; also available for mounting on NEMA C face-type endbells.

Service: Stopping motors or fluid-coupling motors; ratings, 3, 10 or 25 lb-ft continuous duty, 15 or 35 lb-ft intermittent; self-adjusting for lining wear; brake torque remains constant; 2 machines may be run off same motor.

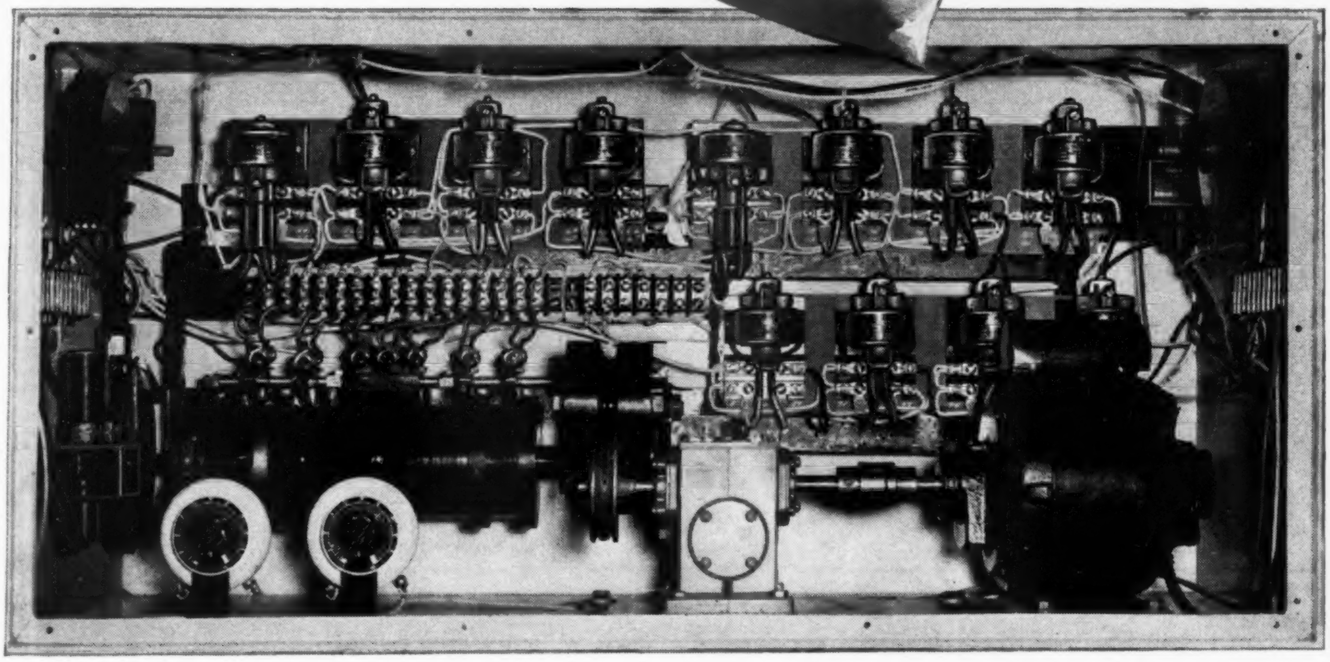
Design: Spring-applied, solenoid-released brake with "doughnut" design solenoid that permits shaft to extend through brake; direct-action solenoid operates without linkages; manual release included to permit rotation with current off; one-piece dustproof cast housing, easily removed, with 4 machine screws for mounting.

For more data circle MD 16, Page 189

ADLAKE RELAYS AT WORK—

One of a series of advertisements on specific ADLAKE applications.

Dependable Control is IN THE BAG



with Adlake Mercury Relays

In manufacturing sugar and flour bagging machines, J. D. Merrifield & Son, of Rocky Ford, Colorado, rely on ADLAKE Mercury Relays. The 12 Mighty Midget Relays and 2 Time Delay Relays shown in the illustration above operate in the controls of one of their automatic scales, handling the control current which the sensitive contacts operating with the balance could not handle.

Like all ADLAKE Relays, they are sturdily constructed for continuing dependability without maintenance. They are hermetically sealed . . . armored against vibration . . . silent and chatterless.

Find out how ADLAKE Relays can assure trouble-free, low-cost operation in your business. Write for free illustrated Relay Catalog . . . no obligation, of course. Address The Adams & Westlake Company, 1128 N. Michigan, Elkhart, Indiana.

EVERY ADLAKE RELAY BRINGS YOU THESE "PLUS" FEATURES:

• HERMETICALLY SEALED—dust, dirt, moisture, oxidation and temperature changes can't interfere with operation • SILENT AND CHATTERLESS • REQUIRES NO MAINTENANCE • ABSOLUTELY SAFE • MERCURY-TO-MERCURY CONTACT—prevents burning, pitting and sticking

THE Adams & Westlake COMPANY

Adlake 95th year of serving the transportation and building industries

Established 1857 • ELKHART, INDIANA • New York • Chicago

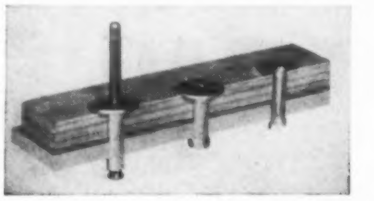
Manufacturers of ADLAKE Hermetically Sealed Mercury Relays

NEW PARTS AND MATERIALS

BLIND RIVET — 17

. . . fastens soft materials to metal frames

Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.



Large head area provides a good-sized bearing surface for fastening thin or soft materials.

Designation: R949, R974.

Size: 1/8, 3/16 or 1/4 diam.

Service: Fastening foil, plywood, Masonite, Bristol board or insulation to metal frames; installed by one person from one side of work.

Design: Pull-through (R949) or self-plugging (R974) types; available in aluminum or steel; large head diameter.

For more data circle MD 17, Page 189

FLUSH LATCH — 19

. . . withstands severe service conditions

Hartwell Co., 9035 Venice Blvd., Los Angeles 34, Calif.

Originally developed for locomotives, this large-size latch is for use under heavy vibration or misalignment conditions.

Designation: H-5150.

Size: 5.66 in. long, 3.75 in. wide, 2.52 in. clearance required from back side of door or panel; trigger offsets (door thickness) from 0.094 to 0.500-in.

Service: Access-panel or inspection-door locking under vibration conditions or where heavy service is likely to cause alignment variations to 1/8-in.

Design: Spring-loaded contact button on bolt maintains closure; steel pins and spring; stainless steel, cold-rolled steel, or heat-treated aluminum-alloy latch; anodized or cadmium plate finish.

Application: Locomotives, aircraft.

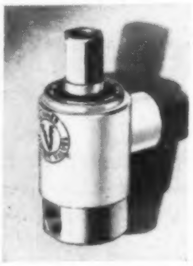
For more data circle MD 19, Page 189

SOLENOID VALVE — 18

. . . designed for explosionproof service

Skinner Electric Valve Div., Skinner Chuck Co., 40 Belden Ave., Norwalk, Conn.

Essentially the same as the company's V5 type, this valve is modified to meet Underwriters Laboratories' requirements.



Designation: X5.

Size: 1 3/4-in. diam plus 3/16-in. conduit extension; height (2-way valve) 3 in., (3-way valve) 3 31/32 in.; 1/8 or 1/4-in. NPT ports.

Service: For hydraulic systems; standard pressure ratings; meets UL requirements for Class I Group D explosive atmospheres; interchangeable with standard valves; all brazed and welded joints are tested under high pressure; operates on ac or dc in wide range of voltages and frequencies; power, 10 w.

Design: Two-way normally-open or closed, or 3-way normally-open, closed or directional flow; solenoid operated; electrical conduit may be rotated to any position; valve may be mounted as desired; soft leakproof spring-loaded seals; stainless steel internal parts; most types available with metering.

For more data circle MD 18, Page 189

HEAVY-DUTY CASTERS — 20

. . . have double ball-race swivels

Bassick Co., Bridgeport 2, Conn.

Both swivel and rigid casters are available, with roller-bearing wheel-hub construction.

Designation: SKH-99 (swivel); SHH-98 (rigid).

Size: Wheel diam, 8 in.; tread width, 2 1/2 in.; overall height, 9 13/16 in.; swivel radius, 6 7/16 in.; top plate size, 5 in. x 6 3/4 in.; thickness, 1/4-in.

Service: Loads up to 1400 lb for semisteel wheel, 560 lb (association standard) for rubber-tread wheel; swivel-bearing surfaces are fully hardened for long life; king pin is designed for high strength.

Design: Rigid, or swivel with double ball-race; semisteel wheel, or aluminum wheel with soft-rubber treads; roller bearing wheel-hub construction; machined steel stud washer locked around king pin provides hardened bearing surface for one ball thrust bearing on swivel model and provides added strength; ball cup is projection-welded to horn.

For more data circle MD 20, Page 189

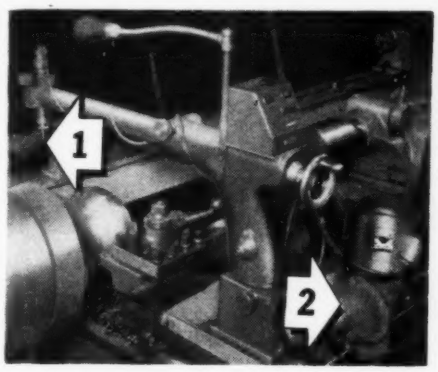
Electronic Duplicator Greatly Increases Machine Tool Output

Increase in production rates of as much as 600% have been reported from the use of the VOSS-RAYTHEON Electronic Duplicators in conjunction with lathes or other equipment for all types of turning and boring operations.

The Duplicator produces a rapid, accurate means of duplicating even extremely difficult contours, without the constant attention of a skilled operator.

Method of Operation

The illustration below shows the Duplicator applied to an engine lathe. A stylus (1) traces the contours of



a template conforming to the shape to which the work is to be machined. Motion of this stylus transmits a signal to the electronic control unit. The signal depends on the curves or turns made by the stylus, and on lateral, longitudinal or diagonal pressure.

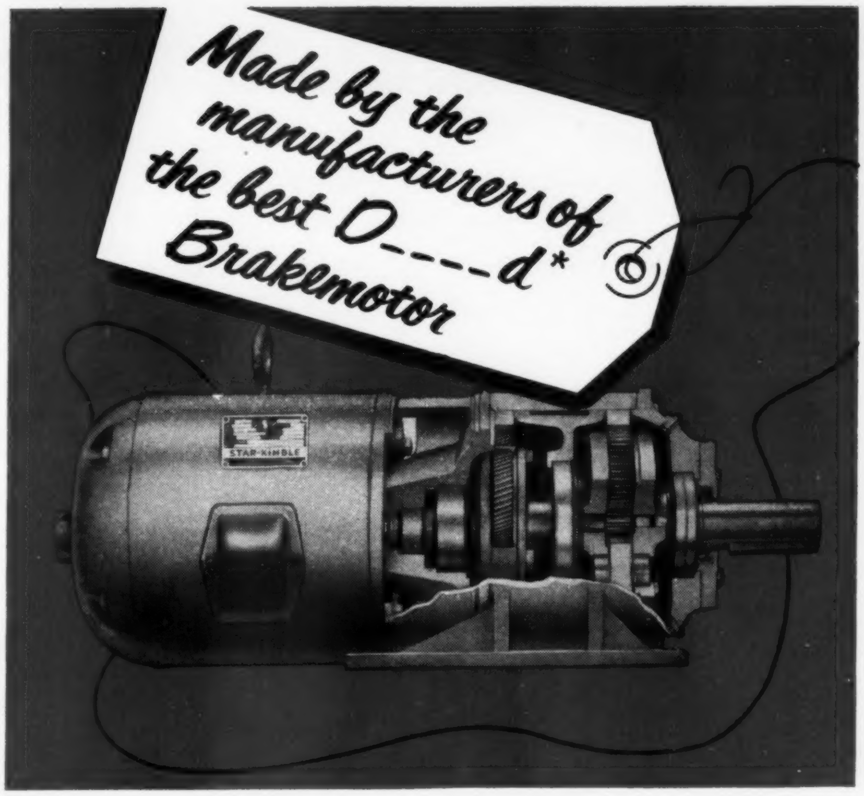
Gearmotor Drives Compound or Cross Slide

The electronic control unit, in turn, governs the operation of a Star-Kimble Gearmotor (2), which drives the compound or cross slide. This Gearmotor is an integrally designed right-angle unit with an aluminum housing. For precise duplication the Gearmotor is designed to provide 300 revolutions for 1 inch of cutting tool movement.

For other applications requiring speed reduction, Star-Kimble supplies Gearmotors with a wide choice of speed ratios ranging from 2.5:1 to 97:1. All sizes and types are designed with an extra margin of safety for handling overloads. All Star-Kimble Gearmotors meet AGMA specifications.

Information on Gearmotor ratings and features is contained in Bulletin B-601, available on request from Star-Kimble Motor Division of Miehle Printing Press and Mfg. Co., 201 Bloomfield Avenue, Bloomfield, New Jersey.

Advertisement



PLANETARY DRIVE REDUCES WEAR... LENGTHENS LIFE of Star-Kimble Gearmotors

THE planetary gear speed-reducing system used and proved for a quarter of a century in Star-Kimble Gearmotors distributes the bearing load uniformly and reduces the risk of wear.

Helical gears of the planetary system are precision-shaved in Star-Kimble's own plants for the continuous tooth contact that assures quiet operation and long life.

Moving parts within the sturdy reducer housing maintain a constant fine spray of lubricant from an oil reservoir to the bearings and gears. Oil seals prevent leakage.

Tapered roller bearings on output shaft eliminate end play—allow Gearmotor to be mounted in any position.

Most important advantage of all is the fact that every Star-Kimble Gearmotor is an integrally designed, integrally built unit. All parts are Star-Kimble engineered to work smoothly and efficiently together—all motors, gears and other major components are produced by Star-Kimble.

*Demanded by industry for tough start-and-stop jobs.

For the facts on Star-Kimble Gearmotors, write for a copy of Bulletin B-601.

STAR-KIMBLE

MOTOR DIVISION OF MIEHLE PRINTING PRESS AND MFG. CO.

201 Bloomfield Avenue Bloomfield, New Jersey

NEW PARTS AND MATERIALS

IRIDESCENT PASTE 21

. . . for polychrome or metallic finishes

Aluminum Co. of America, 801 Gulf Bldg., Pittsburgh 19, Pa.

Greater two-tone flash and sparkle is claimed for this aluminum pigment.

Designation: Aluminum Tinting Paste 222.

Service: Tinting automotive or hammer-tone finishes to obtain iridescent metallic effect; does not interfere with true color values; gives depth of finish; characterized by an absence of seeding.

Form: Paste.

Properties: Aluminum metal content, 65%; specific gravity, 1.47; weight per solid gal, 12.245 oz; bulking value, 0.082-gal per lb.

For more data circle MD 21, Page 189

GLASS FIBER TUBING 23

. . . impregnated with Teflon

Resistoflex Corp., 39 Plansoen St., Belleville 9, N. J.

This tubing is claimed to be the first thin-wall tubing or pipe to incorporate the properties of Teflon.

Size: $\frac{3}{8}$-in ID or larger; wall thickness, $\frac{1}{32}$ to $\frac{1}{8}$-in.; length, 2 ft; longer lengths and heavier walls upon specification.

Service: High heat and chemical resistance; rigidity and strength in tubing with wall thickness down to 0.030-in.; good dielectric properties.

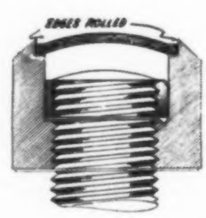
Design: Wound glass-fiber cloth impregnated with Teflon (tetrafluorethylene resin).

For more data circle MD 23, Page 189

LOCKING CAPNUT 22

. . . resists vibration, moisture, corrosion

Security Locknut Corp., 1815 N. Long Ave., Chicago 39, Ill.



Locked on the bolt by a spring-steel insert, this capnut provides protection against corrosion or damage of the bolt.

Designation: Caploc.

Size: $\frac{3}{8}$ to 3 in. standard thread sizes with height designed to fit application.

Service: Locking fastening without necessity of being wrenched against bearing surface; load or stress is borne by nut body, with retainer functioning solely to prevent turning of nut; protects bolt end and threads from moisture, corrosion, mutilation or abrasion; may be removed and reused.

Design: Heat-treated alloy spring-steel insert, elliptical in shape, is forced back into round by the bolt; locking action thus exerted is transferred to nut by an ear on the insert, preventing the nut from turning; locking insert is press-fitted into counterbored hole in nut crown, and is permanently assembled to nut.

Application: Pneumatic hammers, rock drills, conveyors, locomotives, power shovels and tractors, pumps, compressors, presses and forging hammers, materials handling equipment.

For more data circle MD 22, Page 189

HERMETICALLY SEALED RELAY 24

. . . meets all military specifications

General Electric Co., Control Dept., Schenectady 5, N. Y.

Provisions of the Joint Military Service Specification for Relays (MIL-R-6106) and the Air Force-Navy Aeronautical Standard (AN-3304) are met by this relay.

Designation: CR2791G.

Size: $1\frac{7}{16}$ in. square, $2\frac{1}{16}$ in. high, top to mounting base; weight, 4.9 oz.

Service: Contacts are rated 3 amp with 28 v dc or 115 v 400-cycle ac resistive load, 1.5 amp with inductive or motor load; withstands salt spray, humidity, sand and fungi; voltage surges to 1500 v; coil voltage, 24 v dc, with 29 v dc max; 104 amp max current rating; max pickup voltage—18 v, release—7 v max, 2 v min; operating time, 23 millisec max; release time, 5 millisec max; temperature, −67 to +158 F; withstands vibration in excess of 5 to 55 cps with max excursion of 0.060-in; shock, 50*g*.

Design: Four-pole double-throw; silver contacts on beryllium-copper contact fingers; stack insulation, glass-reinforced polyester; drawn-steel, hermetically sealed housing, filled with dry nitrogen, is tin-plated and gray enameled; solder-hook or plug-in pin terminals.

For more data circle MD 24, Page 189

NEW PARTS AND MATERIALS

VARIABLE-SPEED DRIVES 25

. . . with integral single-reduction gearing

Sterling Electric Motors Inc., 5401 *Anaheim-Telegraph Rd., Los Angeles* 22, *Calif.*

A 25-hp model with a speed variation of 4:1 and output speeds of 81 to 324 rpm is illustrated.

Designation: KFEA.

Size: 20, 25 hp.

Service: Variable output speed 728 rpm and lower; speed variation in 2:1, 3:1 or 4:1 ranges; belt tension is in proportion to load, so that belt slipping is eliminated and speeds are accurately maintained with varying load.

Design: Variable-speed belt drive with single-reduction helical gearing; positive oil seals; herringbone motor rotor; dripproof or splashproof construction.

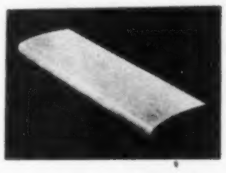
For more data circle MD 25, Page 189

POROUS FILTER 27

. . . of smooth-surface stainless steel

Micro Metallic Corp., 30 *Sea Cliff Ave., Glen Cove, N. Y.*

Surface smoothness is comparable to commercial rolled stainless-steel sheet.



Size: Filter assemblies for $\frac{1}{4}$ to 10 in. pipe size; also in sheet.

Service: Filtering liquids or gases; flow capacities up to 200 cfm of air per sq ft of filter surface at 10 psi pressure differential, or 20 gpm of water per sq ft at 10 psi differential; high mechanical strength, with shear strength in 60,000 psi range.

Design: Smooth-surface sheet with pore diameters from 20 microns down to zero; standard in type 304 stainless steel, specials in types 309, 316 or 347 stainless, also nickel-base alloys such as Monel, and cobalt-base Stellite L-605 for high-temperature service.

Application: Chemical equipment, aircraft.

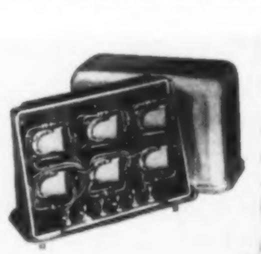
For more data circle MD 27, Page 189

HERMETICALLY-SEALED ENCLOSURE 26

. . . for stepping switch or groups of relays

Automatic Electric Co., 1033 *W. Van Buren St., Chicago* 7, *Ill.*

Entire relay circuits can be contained in this small-size enclosure.



Size: $4\frac{1}{8}$ in. long, $2\frac{3}{16}$ in. wide, $3\frac{1}{8}$ in. high.

Service: Protecting relay circuits or stepping switch from moisture, ice, dust, fungus, corrosion and salt spray; mounting protects relays against shock and vibration; 6 relays or one miniature stepping switch (specially designed to fit) can be enclosed; rotary stepping switch has max self-interrupted speed of 80 steps per sec, is available with 10 positions plus "home" in 1, 2 or 3 levels, or 20 or 30 positions plus "home" in one level, for operating voltages to 110 v dc.

Design: Enclosure is hermetically sealed with atmosphere of dry inert gas; connections are made through terminals on mounting base.

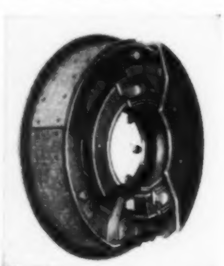
For more data circle MD 26, Page 189

ELECTRIC BRAKE 28

. . . stops heavy equipment in minimum time

Warner Electric Brake & Clutch Co., Beloit, Wis.

Many heavy-duty applications which formerly required mechanical or hydraulic systems for "start-stop" operation can now be converted to an electrical system.



Size: 15-in. diam, 3-in. width; requires 5 in. axial mounting space.

Service: Stopping heavy equipment; rheostat controls and cushions torque within wide range of settings; braking torque builds up quickly from 0 to maximum value in a period long enough to prevent shock; high heat dissipation rate; available for 6 or 90 v dc.

Design: Two-shoe expanding brake; brake is mounted stationary; as magnet is energized brake shoes are expanded against rotating drum.

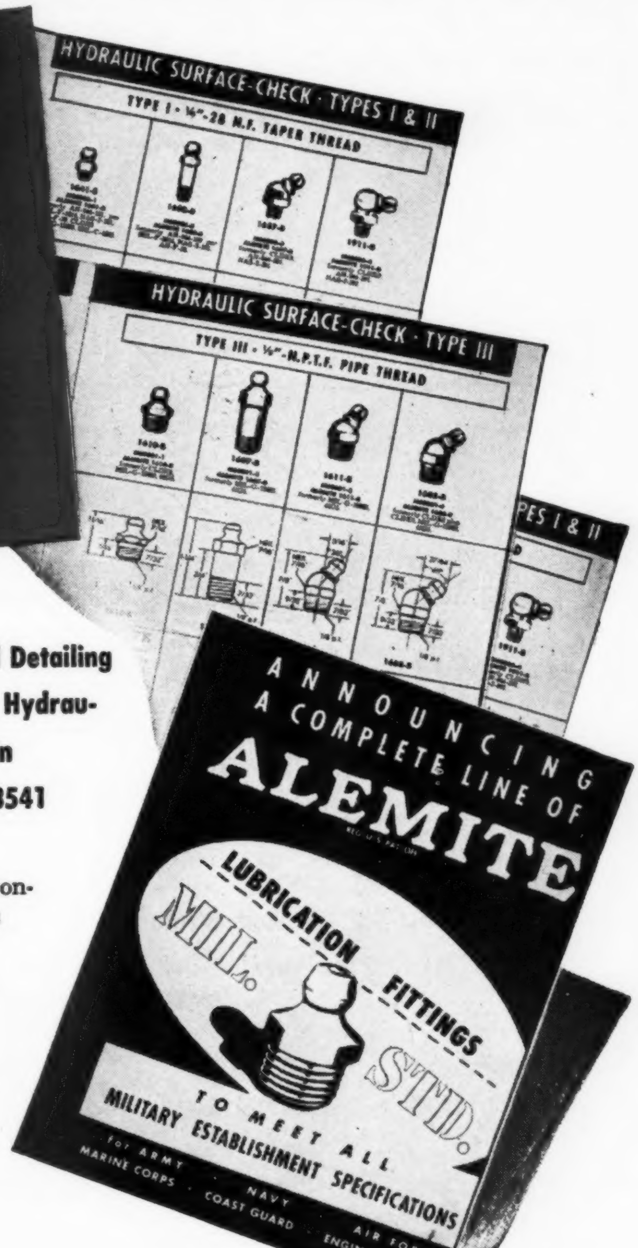
Application: Heavy woodworking machines and machine tools; steel-mill machinery.

For more data circle MD 28, Page 189

Important!

to everyone designing and making equipment for the armed forces

THIS NEW...
ALEMITE LUBRICATION FITTING CATALOG



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ENGINEERING DEPARTMENT

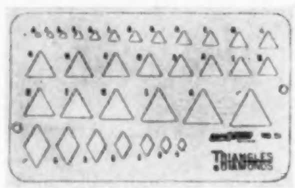
EQUIPMENT

For additional information on this new equipment, see Page 189

PLASTIC TEMPLATE 29

. . . for triangles and diamonds

Rapidesign Inc., P.O. Box 592, Glendale, Calif.



This template has 26 triangles and 7 diamonds.

Designation: 51.

Size: 7-in. wide, 4-in. high, 0.030-in. thick; equilateral triangles have $\frac{3}{32}$ to 1 in. sides, in increments of $\frac{1}{32}$-in. to ¾-in., plus $\frac{13}{16}$, ⅞ and 1 in; diamonds have long diagonals from ¼ to 1 in. in increments of ⅛-in.

Service: General-purpose drafting; cutouts have pencil allowance for accuracy; diamonds up to 2 in. may be made by using triangles back-to-back.

Design: Cutouts are precision smooth; matte finish plastic.

For more data circle MD 29, Page 189

SMALL-SIZE CALCULATOR 31

. . . has speed and accuracy of desk calculator

Curta Calculator Co., 5543 S. Ashland Ave., Chicago, Ill.

Having the portability of a slide rule, this calculator is claimed to be faster than a desk-size unit with comparable accuracy.

Size: Approximately 1¾-in. diam, 3½-in. long; weight, 8 oz.

Service: Adds, subtracts, multiplies, divides, figures square roots, factors, cubes and percentages; carries to 5 decimal places, totals to 99 billion.

Design: Precision Swiss movement; 3 sets of dials; rubber-lined metal case is included.

For more data circle MD 31, Page 189

COPYING MACHINE 30

. . . low cost for medium volume

Charles Bruning Co. Inc., 125 North St., Teterboro, N. J.

This whiteprinter is claimed to be the only machine in its price class with a full 46 in. printing width.

Designation: Copyflex 20.

Size: Printing width, 46 in.; machine is 56-in. high, 70-in. wide, 56-in. deep; weight, 900 lb.

Service: Making black-on-white prints of drawings or business forms from translucent originals; opaque originals can be reproduced by making intermediate print on reflex film, which is processed without darkroom or tray development; takes roll stock or multiple cut sheets inserted side-by-side; copies can be made with colored lines or on colored paper.

Design: Copying machine feeds and delivers from front; requires only connection to 115 v, 60-cycle line for installation.

For more data circle MD 30, Page 189

HAND PYROMETER 32

. . . measures temperature to 1500 F

General Electric Co., Meter and Instrument Dept., Schenectady 5, N. Y.

Surface, liquid, gas and molten-metal temperature can be quickly measured.

Designation: FH-1.

Size: Instrument—9 in. x 5 in., weight, 1.5 lb; case—11 in. x 20 in., weight (complete), 9.5 lb; rigid arm, 14 in. long; flexible arm, 34 in. long; scale length, 3½ in.

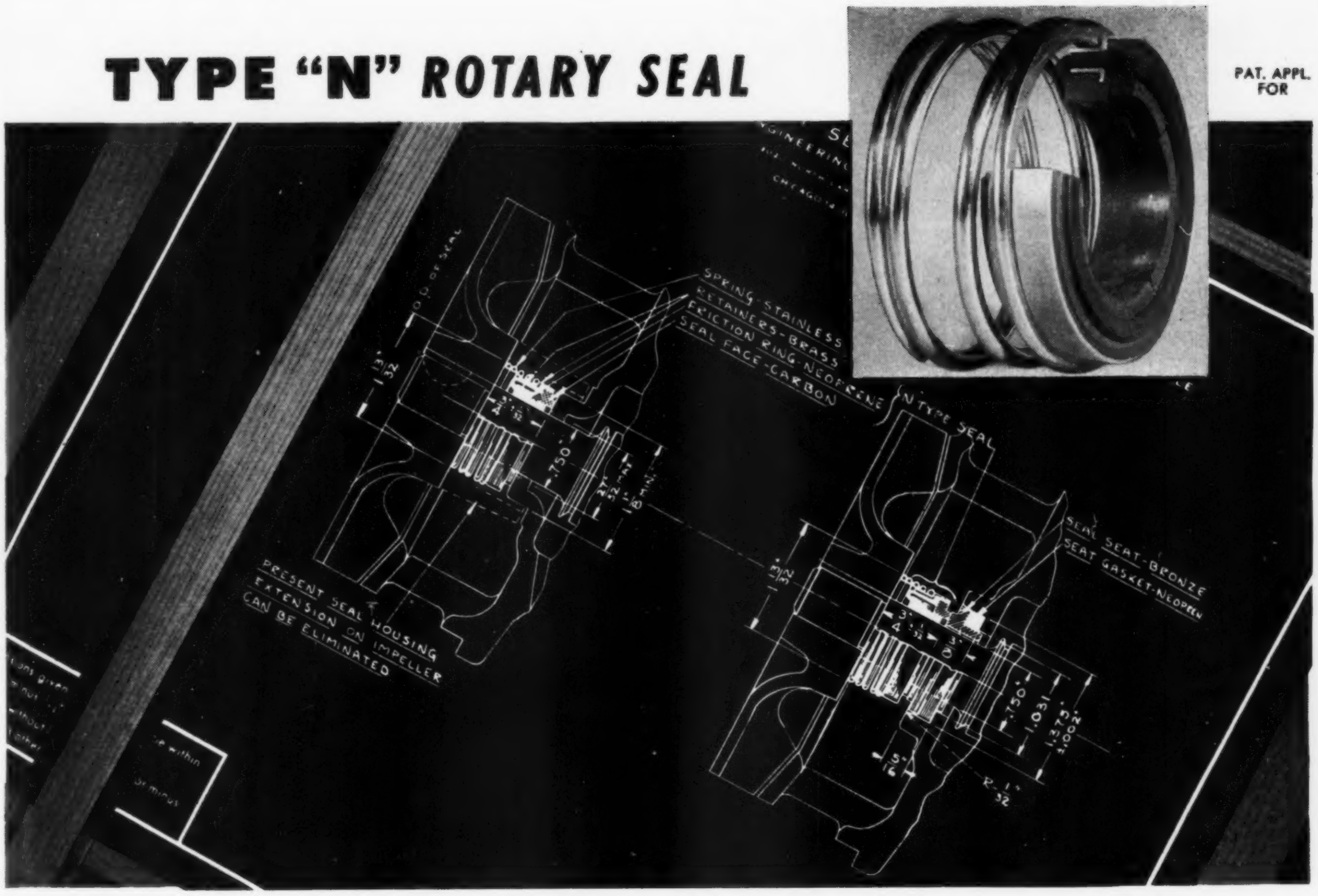
Service: Temperature measurements in 0-500 F and 0-1500 F ranges; calibrated accuracy, ±2½%; automatic cold junction compensation on both ranges; high response speed; meets specifications of JAN-I-6.

Design: Thermocouple and millivoltmeter with surface tip, 2-prong contact tip and immersion tip; chromel-constantan is used for thermocouples; plastic pyrometer case is splashproof, dusttight and moisture resistant; padded wood carrying case.

For more data circle MD 32, Page 189

TYPE "N" *ROTARY SEAL*

PAT. APPL. FOR



engineered for new *Production-line* efficiency

Type "N" Rotary Seal eliminates "watchmaker" assembly jobs, by providing the Seal pre-assembled and ready to incorporate into the equipment. This unit construction means no loose parts to deal with—no delicate adjustments or fittings to make. In short, Type "N" Rotary Seals are thoroughly efficient production-line adaptations of a time-tested principle, worked out especially to meet the increasingly difficult sealing problems brought about by higher shaft speeds or adverse lubrication conditions.

Rotary Seal engineers can quickly adapt this new Seal to any of a wide range of applications. Inasmuch as Type "N" has been designed particularly to meet mass production conditions, it is not available in small quantities for all shaft sizes.

THE ROTARY SEAL PRINCIPLE

is the original approach to a practical solution of a universally troublesome problem. Our booklet "Sealing with Certainty" explains and illustrates the principle. We're glad to send it to you without obligation. Full description of Type "N" is included.

SEND FOR YOUR COPY TODAY

THE ROTARY SEAL COMPANY
mechanical seals for rotating shafts

MEN OF MACHINES

Allen Latham Jr.

Election of **Allen Latham Jr.** as a vice president of Arthur D. Little Inc., Cambridge, Mass., consulting research and engineering firm, was announced at the annual meeting of stockholders and directors. Mr. Latham will continue as technical director of the Mechanical division and, in addition, will be responsible for overall operation of the division. Mr. Latham received a B.S. degree in mechanical engineering from Massachusetts Institute of Technology in 1930. He worked for five years with Du Pont in West Virginia on process development at the synthetic ammonia plant. He spent another five years with the Land-Wheelwright Laboratories, which later became the Polaroid Corp. His duties there included design, construction and operating procedures, with additional managerial functions. Joining Arthur D. Little in 1941, Mr. Latham developed the Kleinschmidt vapor-compression distillation equipment after Dr. Kleinschmidt left the company to join the U. S. Navy. The greater part of Mr. Latham's time during 1942 to 1945 was devoted to war projects. During the past few years he has worked extensively on extreme low temperature equipment, co-ordinating design, development and fabrication of this equipment.

♦

Gus M. Bagnard has been appointed chief engineer of Chiksan Co., Brea, Calif. Mr. Bagnard recently was in charge of the newly-created design and development division of the engineering department.

♦

Mycalex Corp. of America, Clifton, N. J., has announced the appointment of **J. H. DuBois** as vice president in charge of engineering. Mr. DuBois held the position of manager of new product development for Plax Corp., served as commercial engineer in plastics for General Electric Co., and engaged in pioneer plastics mold development work for the Gorham Co. He has authored and co-operated in

*

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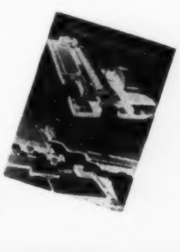

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the writing of technical books and periodical articles and is advisory editor for several journals. He is an active member and former national president of the Society of Plastics Engineers Inc., and a member of the Society of the Plastics Industry, U. S. Naval Institute and the American Ordnance Association.

•

W. J. Langacher

The Aetna-Standard Engineering Co., Pittsburgh, has announced the appointment of **W. J. Langacher** as chief engineer. He has been associated with Aetna-Standard for many years and has held several positions covering the company's major product lines of pipe and tube, flat-rolled and drawbenches. Mr. Langacher served as chairman of the Youngstown Section of The American Society of Professional Engineers during 1950-51. Aetna-Standard has also announced the appointment of **G. E. Mandry** as assistant chief engineer of the pipe and tube division.

•

Hal W. Poole has been named manager of engineering in General Electric Company's newly-formed industry control department in Schenectady, N. Y. Mr. Poole joined GE on the test course in 1934, after graduating from Kansas State College with a B.S. degree in electrical engineering. Following assignments in industrial control engineering and the steel mill section of industrial engineering, he was made manager of the machinery section in industrial engineering in 1946. That same year he returned to the steel mill section as manager.

•

With headquarters in Whittier, Calif., **Edmond M. Wagner** has been appointed to the newly created position of director of engineering and manufacturing for the West Coast operations of Ekco Products Co.

•

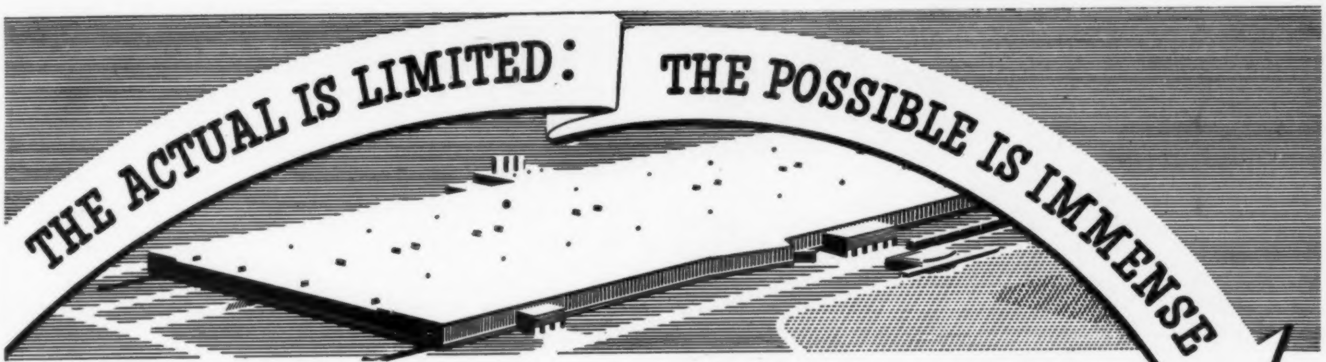
John Senft has joined Hodell Chain Co., Cleveland, division of National Screw & Mfg. Co., as consultant in its engineering department.

•

Dr. Clifford E. Berry, authority in the field of mass spectrometry, has been promoted to the office of assistant director of research at Consolidated Engineering Corp., Pasadena, Calif.

•

Recent promotions among management personnel of Precision Castings Co. Inc., Fayetteville, N. Y., include those of **William J. During** to executive vice president of the company and **J. J. Punke** to vice president. Mr. During joined Precision in 1923 as



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

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THE proper use of welded steel strengthens the construction of many products while cutting costs 50%.

As shown in Fig. 3, a simple duplication of a design in mild steel generally reduces material costs to as little as 35% of traditional gray iron construction. However, when designs utilize the inherently greater strength and rigidity of steel, still fewer pounds of metal are required and material costs can be cut to 15%. Ultimately, the efficient use of formed engineering shapes from sheet or plate can eliminate further metal, cutting the material expense to as low as 5%. With these substantial savings in material costs, the designer has a latitude of 35% to 45% in which to fabricate and still realize overall cost savings of 50% in the manufacture of his products.

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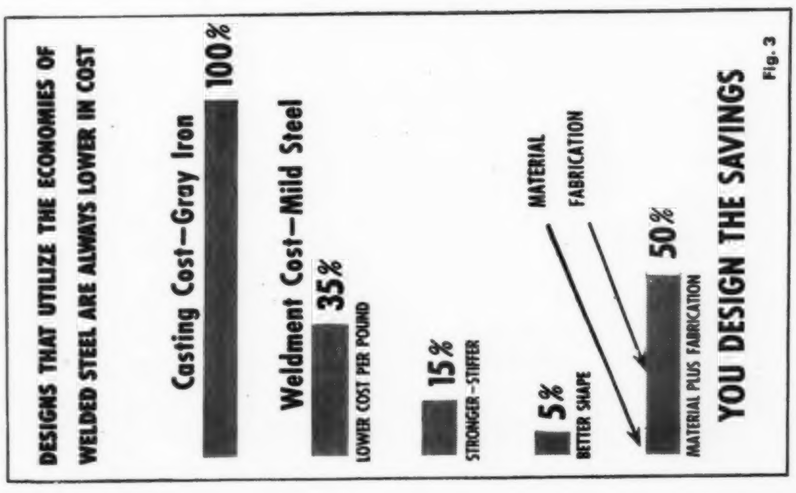

Fig. 3

PROPER DESIGN IN WELDED STEEL ALWAYS IMPROVES PRODUCT AND LOWERS COST

Fig. 1—Original Construction *of hanger. Cost....$5.20. Weight 18 pounds.*

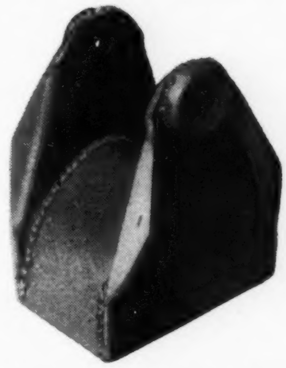

Fig. 2—Present Weldesign in Steel *Saves 52% in cost. Costs....$2.50 Weighs 12 pounds.*

Photos courtesy Dorsey Trailer Company, Elba, Alabama.

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chief engineer and production manager. During World War II he served as consultant to Gen. G. M. Barnes on all nonferrous metal applications, and at the same time was technical chairman of the die casting industry engineering committee. Mr. Punke, who has been chief engineer and factories manager since 1945, joined the company in 1939 as development engineer.

♦

A. Gilbert Formel has joined Loewy Construction Co. Inc., a subsidiary of Hydropress Inc., New York, as projects manager for heavy hydraulic presses, die forging and extrusion plants. Mr. Formel was formerly associated with the Preload Corp.; Ford, Bacon and Davis Inc.; and E. B. Badger & Sons Co.

♦

Having joined the firm a year ago as a design engineer with ten years of mechanical engineering experience in aircraft and other industrial firms, **J. A. Wilson Jr.** has been named supervisor of design and drafting for the C. A. Norgren Co. The company recently moved into its new plant in Englewood, Colo., a suburb of Denver.

♦

Chief hydraulic engineer for Aluminum Co. of America since 1938, **James P. Growdon** has been named an engineering consultant on hydraulic and related engineering problems for the company. **B. J. Fletcher,** assistant chief hydraulic engineer, succeeds Mr. Growdon as chief hydraulic engineer.

♦

As part of the program of consolidating the operations of Economy Pumps Inc., as a division of the C. H. Wheeler Mfg. Co., Philadelphia, **Robert J. MacMeekin** has been transferred from Hamilton, O., as chief engineer of the pump division of the parent company. At the same time **H. O. Fullam** was appointed chief industrial engineer in charge of methods engineering, tool engineering, tool manufacturing and maintenance of plant equipment for C. H. Wheeler Mfg. Co.

♦

Appointment of **John Nuber** as assistant chief engineer and **Stewart Millar** as supervisor of engineering standards and development has been announced by Detrex Corp., Detroit. Mr. Nuber will be in charge of all technical phases of design and estimating for the company's industrial process cleaning division, which includes solvent-vapor degreasers and alkali washer equipment. Mr. Millar's new duties will concern design improvement of present industrial cleaning equipment, together with the study of ways of improving the design of accessory equipment for metal cleaning machines.

♦

Associated with the company since 1930, **Paul S. Gruber** has been appointed assistant chief engineer of the engineering division of Ferro Corp., Cleveland. For the past two years Mr. Gruber has been working with General Electric Co. on the installation of porcelain enameling furnaces in the new GE appliance manufacturing plant in Louisville.


CRUTCH PADS
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HERCULES
CELLULOSIC PLASTICS

THE ENGINEER'S Library

Graphic Aids in Engineering Computation

By Randolph P. Hoelscher, professor, University of Illinois, Joseph Norman Arnold, associate professor, Purdue University, and Stanley H. Pierce, associate professor, University of Illinois; published by McGraw-Hill Book Co., New York; 197 pages, 6 by 9 inches; clothbound; available through MACHINE DESIGN, *$4.50 postpaid.*

Engineering computations, especially those involving repetitive solutions, are often facilitated by the use of graphical and mechanical aids. This text, which is the outgrowth of a series of notes successfully used in teaching for over ten years by the authors, is designed for the use of those who wish to attain an understanding of the principles and methods of operation of slide rules and the construction of alignment charts. Knowledge of drawing and analytical geometry is presumed.

The introductory chapter covers the use of standard slide rules and is followed by a chapter dealing with the derivation of empirical equations from experimental data. Alignment chart (nomograph) construction is explained next and instructions on troublesome items in actual chart preparation are given in detail. Succeeding chapters go into graphical differentiation and integration, the construction of alignment charts by means of determinants, and the utilization of special slide rules. In the concluding chapter, movable scale nomographs are discussed.

□ □ □

Plastics Molding

By John Delmonte, consulting engineer; published by John Wiley & Sons Inc., New York; 493 pages, 5¾ by 9 inches, clothbound; available from MACHINE DESIGN, *$9.00 postpaid.*

Concentrating upon a major division in the large plastics field, this book presents a study of the plastics molding industry, its materials, equipment, and techniques. In the approach used by the author, material flow is discussed with respect to its effects on the methods of handling the flow. Emphasis is placed on the selection and adaptation of equipment to molding problems.

Beginning with a brief survey of the characteristics of molding materials, the text continues with a dis-

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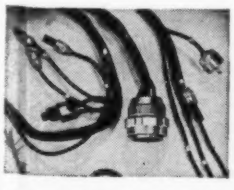

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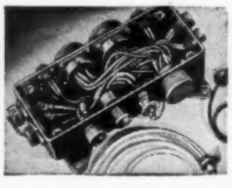

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cussion of hydraulic and mechanical pressure systems, and molding plant valving and piping. Succeeding chapters deal with equipment for material preparation, compression and transfer molding, injection molding, and extrusion. Two chapters on mold design are also included. Concluding chapters cover finishing accessories, instrumentation, and plant layout.

Manufacturers' Publications

Denison JICircuit Guide: Developed to simplify the drawing and understanding of JIC symbols in hydraulic circuit diagrams, this 32-page booklet together with an accompanying plastic drawing template have been made up in kit form. The introductory section of the booklet contains a complete list of the standard symbols approved for industrial equipment. Succeeding sections illustrate the use of the symbols as applied to Denison equipment. The template provides basic elements of all JIC symbols to facilitate the drawing of circuits. Size of the kit is 6 by 9 inches; available by request on company letterhead from the Denison Engineering Co., Columbus 16, Ohio.

Practical Dimensioning: Written by E. C. Helmke, this booklet was originally presented as a paper before the American Society for Engineering Education. An abstract of this paper appeared in MACHINE DESIGN, February 1952, Pages 172-174. Containing 40 pages, the text uses 26 annotated drawings to illustrate good and bad machine dimensioning practices. Emphasis is placed on avoiding tolerance accumulation, placing base lines correctly, and dimensioning to insure certain manufacturing procedures. Copies of the 8½ by 11-inch paper-bound booklet may be obtained from Gisholt Machine Co., Dept. MB, 1245 E. Washington Ave., Madison 10, Wis.; no charge for single copies, nominal charge for multiple copies.

Incentive Management: The incentive system is viewed not merely as a mechanical method applied to the existing structure of a company, but as a whole new philosophy around which the company is built. This philosophy not only involves consideration of workers' production and wages, but the larger issues concerning basic personnel attitudes, advancement, security, unions, and corporate size and financing.

In order to gain the benefits possible through incentive management, "three demands are made on managers: understanding of the human urges involved, honesty of purpose, and ability to lead so that the worker accepts management as a teammate." If these three basic concepts are well applied, and the practical considerations of profit sharing, production rates, etc., are well planned, an incentive management system stands a good chance of being a huge success. Although many of the statements in the book are generalized from the author's own inti-

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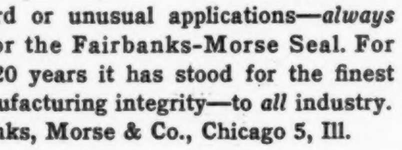

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mate knowledge of incentives, supporting data is given in the form of an appendix showing, in facts and figures, the results of applying the incentive system at Lincoln Electric. Written by James F. Lincoln, the book is 5¾ by 9 inches in size, clothbound, and contains 288 pages. Copies may be obtained for $1.00 from the Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, O.

Tool Steel Handbook: According to the preface, the aim of this 197 page, clothbound handbook "is to make available in as compact form as possible, a relatively complete picture of the Allegheny Ludlum tool steels, their properties and treatments and the special forms in which they are available." The introductory chapter presents charts and tables of data on properties, analyses, and application. Chapter 2 contains detailed descriptions of the various tool and high-speed steels arranged in alphabetical order. Succeeding chapters deal with: tool steel products, Carmet carbide metal, forging and casting division products, and the working of tool and high-speed steels. Weight and machinability tables and general reference information round out this volume which is 7½ by 10½ inches in size. Copies can be obtained on request by users of tool and high-speed steels from Allegheny Ludlum Steel Corp., 2020 Oliver Building, Pittsburgh 22, Pa.

Association Publications

Dollar Savings Through Standards: To encourage European manufacturers to adopt U. S. production methods, this 32-page booklet was prepared for the Economic Co-operation Administration by the American Standards Association. Printed from a report entitled "Survey to Obtain Data to Show Savings Derived from the Use of Standards by American Industry," it presents 140 documented case studies involving 81 industries. Copies of this 8¼ by 11¼-inch booklet are available for $1.00 each from the American Standards Association Inc., 70 East 45th Street, New York 17, N. Y.

Corrosion Testing: Reprinted from the proceedings of the ASTM, this Twenty-Fifth Edgar Marburg Lecture was originally presented before the Society in 1951 by Francis L. LaQue. Methods of corrosion testing, including those sponsored by the ASTM, are reviewed with emphasis focused on precautions to be observed in planning, executing, and interpreting tests. General topics include: atmospheric corrosion studies, relations between rust color and corrosion, effects of alloying elements on the resistance of steels and irons to atmospheric corrosion, comparison of atmospheres, and galvanic corrosion. Illustrated throughout with photographs, charts, curves, and tables, copies of this 6 by 9-inch, 96-page, heavy-paper covered booklet can be procured from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., for $1.50 each.

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PHOTO COURTESY THE WHITE MOTOR CO.

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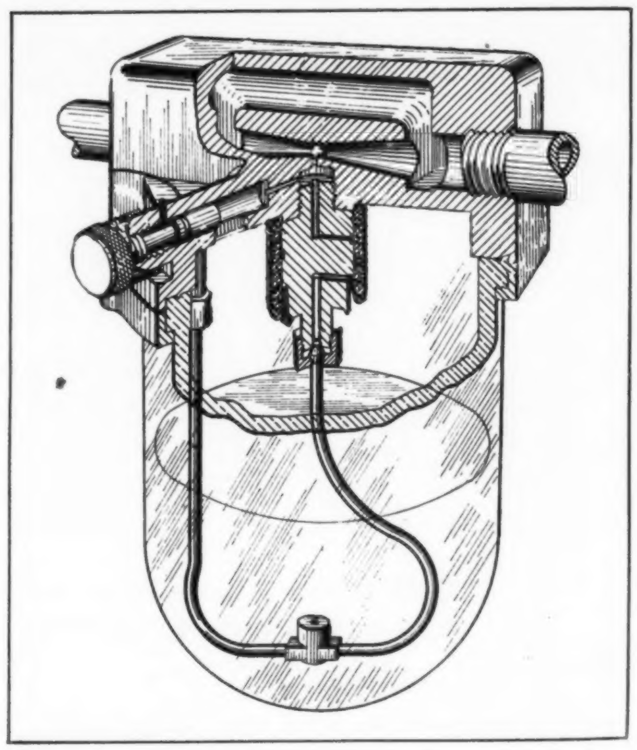
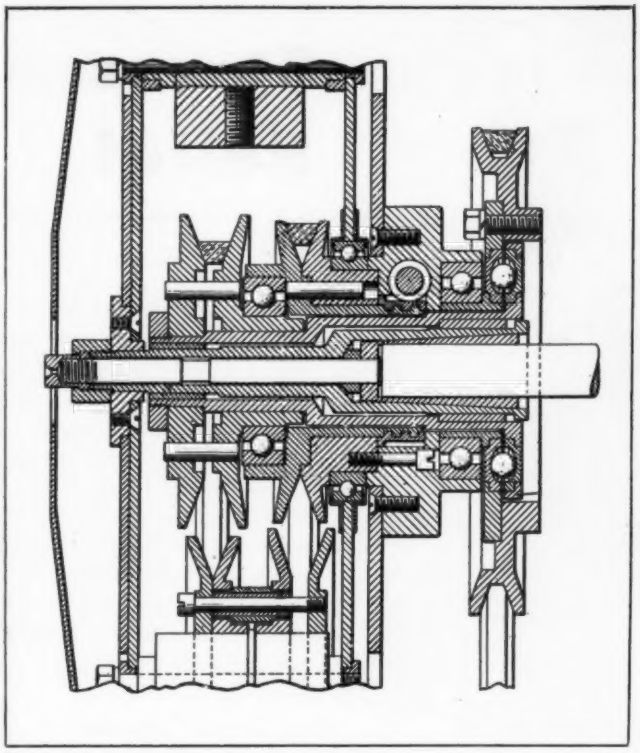
NOTEWORTHY

Patents

CAPILLARY FEEDING enables lubricator unit to supply uniformly vaporized, filtered, slug-free lubricant into air lines supplying pneumatically operated valves, cylinders, motors and similar equipment. Passage of air through the unit when the operating valve of a device in the line is opened creates a pressure impulse in a feeder tube system which pumps oil to keep the tubular-shaped feeder wick saturated. Excess oil delivered returns by gravity to the reservoir. Lubricant absorbed by the wick is fed upward by capillary action to a circular groove on the wick holder from whence it is drawn through inlet holes into a venturi tube in the air line. Aspiratory action of the lubricator is adjustable to meet lubrication requirements of the pneumatic equipment attached to the line. Patent 2,565,691 assigned to Air Appliances Inc. by Peter Ketelsen.



CAMMING ACTION OF BALLS in spherical-bottomed pockets of a built-in drive coupling in a variable speed V-belt drive enable constant output speed to be maintained irrespective of load changes. Ordinarily, when subjected to increased torque requirements, V-belts tend to alter position in the sheaves, causing the speed ratio to change slightly. Load increase in this drive arrangement causes relative an-



gular displacement of the coupling halves, resulting in their separation because of the contour of the ball pockets. Thrust from the driven half of the coupling adjusts the flanges of the variable-pitch sheaves closer together, counteracting the tendency of the drive to slow down. When the load is reduced, the coupling halves return to their normal position, and the sheave flanges spread to their normal spacing. Patent 2,566,-997 assigned to Speed Selector Inc. by William H. Schweickart.

A LISTING of 2339 PATENTS owned by the United States government and available to American businessmen for use without charge has been prepared by the Government Patents Board.

Patents listed cover a wide range of products and processes, new uses for raw materials, and new methods of handling mechanical problems. These patents are on inventions developed in Federal research programs.

Published by the U. S. Department of Commerce, the book contains information first chronologically by Patent Office numbers, giving descriptive titles, names of the inventors, agencies administering the patents, and the industrial classifications under which each invention falls.

The second section gives a cross-reference listing of the patents under 21 major standard industrial classifications indicating the fields to which the inventions apply.

Copies of "Government-owned Inventions for Free Use" may be obtained through field offices of the U. S. Department of Commerce or from the U. S. Government Printing Office, Washington 25, D. C. for one dollar each.

Stress Relief

IN THE first appearance of this column last month we told you a little about J. P. Henderson, retired chief engineer, who would join us on frequent occasions to deliver himself of some of the splinters acquired in long years of dealing with engineers and others. In that column he had some things to say on the classification of engineers into specific personal types. This month he brings the first of his friends on stage.

The Detail Engineer

The scene today is the boss's office, with you (the boss) seated, going through a stack of mail. Another man enters, with a handful of notes, apparently written on several old envelopes.

"Are you busy?"

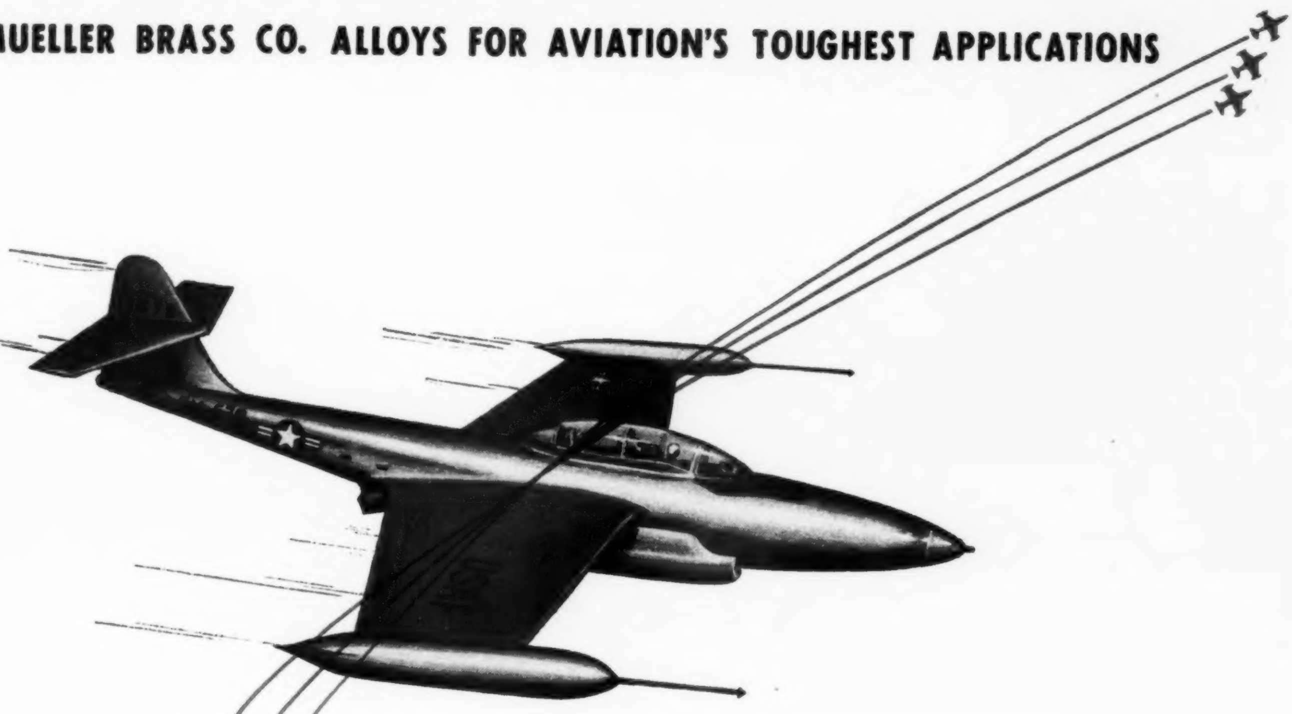
You might as well tell him "No." If you tell him the truth, he'll look hurt and be back later to tell you about it anyway.

"Well sir, you know that Model XX I've been designing? Last week it came through after a funny experience I had in Department 87A. Then, when I told the lab to test it, the belts slipped so badly the first test was no good. We finally got it going through, but we had to look all over the place for belt dressing." If you are a fortunate and experienced executive, you have already learned how to compile your Christmas list, formulate the next ten letters you expect to dictate, explore cautiously the hole in your tooth and make up an excuse for not visiting the dentist this week, while the steady flow keeps on.

". . . and there's so much evidence of wear, that it will never pass the life test."

Finally he's through, and you look at him ruefully. That frowning expression on your face (you hope) is being interpreted as deep thought occasioned by his brilliant

MUELLER BRASS CO. ALLOYS FOR AVIATION'S TOUGHEST APPLICATIONS



"803" • Mueller Brass Co. "803" metal is a high silicon iron-copper bronze that is ideally suited for many difficult applications in jet aircraft. "803" metal has unusually good machinability, and it is extremely ductile. It is non-galling and has excellent mechanical properties at temperatures up to 500°F., factors that account for its wide use as roller bearing cages and other specialty parts in jet engines.

"600" SERIES • "600" series are high strength bearing bronzes that do not contain any hard-to-get tin. They can be forged into relatively complicated shapes that are closer to size and require less machining than sand castings. "600" series metals have a low coefficient of friction and a tensile strength 2½ times that of the cast phosphor bronzes. They are highly resistant to wear and corrosion. These properties make "600" series highly desirable for use as parts on hydraulic equipment, actuators and instruments in jet aircraft. "600" series metals are available in standard or special extruded shapes up to 12' mill lengths. There is a "600" series alloy to suit your special bearing metal needs.

TUF-STUF • Mueller Brass Co. TUF-STUF aluminum bronze alloys have found wide acceptance for jet aircraft parts like the rotor for hydraulic pumps and other vital jet engine parts that must stand up. TUF-STUF alloys are corrosion resistant . . . strong and light and extremely long-wearing. They resist oxidation, even at high temperatures. TUF-STUF alloys are available in the form of forgings, rods and screw machine parts. They fill Federal Specification QQ-B-666, Grade B, and several other variations.

For complete information about "803" metal, the "600" series alloys and TUF-STUF, write today to

82

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summary. Actually, you are thinking:

"Look, man, where is your mind? Why do you suppose I want to clutter up my head with that trash? There are fifty people coming into this office. If all of them did this, they would drive me to quicker retirement. I don't order belt dressing. Why tell me what

you should be telling the laboratory assistant? The only reason I want to hear a word out of you is because tomorrow the president will ask me, 'How is Model XX?' "

I will tell him, "Came through last week. Now on test. Shows some evidence of excessive wear and may need some modification."

The detail engineer has made his daily report. Let's lower the curtain on this painful scene. Apparently, it takes too much imagination for the employee to consider just what the boss is going to do with that information before he wastes his time in spilling it all out. He is the "detail engineer" and he never made a mental summary in his life.

Someone has suggested a cure for such a type. It's learning to report in newspaper style. Consider the newspaper headline. In a half-dozen words you have the major happening. In a few subheads, you get an expanded version. In the first paragraph you get it all. The columns which follow are extended detail.

The boss should get the headlines and the subheads. He should

be asked if he wants the details. If not, he should get the conclusions, or the request for advice as to the next move if such is required.

What about all the mental trash the detail engineer unloaded? Did the boss really need to know it?

No!

If he must unload it, he should save it for his wife.

She also has probably cultivated the habit of not listening.

—J. P. HENDERSON

In his salty way, J. P. points up a moral that is applicable to more than the verbal report to the chief. Intelligent design of a report, verbal or written, is comparable to the competent design of a machine or the dispatch of any engineering assignment. What is required? What is the most practical, direct path?

In future months Henderson will introduce other characters from his extensive rogues' gallery.

They Say . . .

"There is a great burden placed upon the engineering profession; it is not sufficient for us merely to apply the knowledge we have gained during the course of our formal education. As Sam Walter Foss so aptly puts it in his poem, "The Calf Path," which mocks the fact that we follow our pursuits in life even as we have used for centuries roads which were paths made originally by cattle:

> For men are prone to go it blind
> Along the Calf-path of the mind,
> And work away from sun to sun
> To do what other men have done.

Such an application of knowledge places the individual in a status similar to that of a technician who follows his set routine according to the demands made upon him by his superior. It is true that not all of us can be Edisons or Steinmetzes, but we can maintain an awareness of the developments pertaining to our particular fields of engineering. It is possible for us to show originality of thought in the application of the latest developments to our own particular problems." — MARCUS SLOBINS, *Northeastern University*

REPORT ON

Materials

AVAILABILITY of steel will probably be little affected by the preparations for steel-plant shutdown which immediately preceded President Truman's seizure of the steel industry last month. Although the total amount of steel lost was about 825,000 net tons, this amount represents less than one per cent of the total scheduled to be produced this year. At worst, decontrols originally scheduled for late 1952 or early 1953 for carbon steels may be held up a few months longer.

Imminence of decontrol action seems increasingly evident. Already the outlines of an interim control plant to replace the comprehensive CMP plan are taking shape, in the form of a new priority rating called B-5. If, when, and as controls are removed, some method of insuring a constant flow of vital materials to military, Atomic Energy Commission and machine-tool programs will be necessary—and the B-5 rating seems to be designed toward this end. Effective immediately, the new B-5 rating will be extended by producers of products for these major programs to manufacturers of components. These parts suppliers will still continue to get allotments direct from NPA, but the rating is supposed to get quicker action. If CMP is dropped, this limited priority system would probably remain.

Copper Expansion Forecast: Supply of copper, one of the most critical materials, is expected to catch up with demand—in 1955. In this year, say officials of the Defense Production Administration, the total amount of copper available from domestic ore, imports and old scrap will be only 3000 tons short of projected demand. In actual figures, the picture looks like this:

Year	Production (short tons)
1950	2,031,000
1951	1,914,000
1955	2,270,000

These figures represent the ac-

tual amount of copper available for CMP distribution. Strikes and ceiling prices on scrap resulted in the low shipments of copper controlled materials during 1951, and the most significant change in the pattern of distribution of copper over the year was a gradual shift toward an increase in output of brass-mill products at the expense of wire-mill and foundry products.

Aluminum in Electrical Uses: Aluminum has been found to be a valuable substitute for copper in a wide variety of electrical applications. Although its conductivity and strength are lower than copper, aluminum's relative availability makes it highly desirable as an alternate. Although General Electric's copper allocation, for example, is only 40 per cent of its base period usage, a 75 per cent production rate has been maintained in products formerly using copper by substitution of aluminum. Aluminum castings have replaced copper castings, aluminum conductors are used, and heavy equipment such as distribution transformers now contain many aluminum parts.

One of the drawbacks in use of aluminum for electric power transmission is the difficulty of connecting aluminum to copper conductors without deterioration of the aluminum. Until recently aluminum was used mainly in high-voltage transmission lines because fewer connections were required. Recently, however, aluminum conductors have been tested for telephone cable, and are already being used in low-voltage transmission lines.

Review of Titanium: Titanium, hailed as the "wonder metal" and the "asbestos of metals," has for the past few years been the fair-haired boy of the news columns. With recent improvements of the techniques for processing the temperature-resistant metal, the fair-haired boy may soon become a man.

Titanium has a higher strength-to-weight ratio than either aluminum or steel. Its ultimate and yield strengths are somewhat lower than steel's and higher than aluminum's. Its melting point is extremely high (3140 F), but it reacts appreciably with oxygen and nitrogen at temperatures above about 1300 F. The resulting embrittlement and loss of strength restrict

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its use to a service range below that of high-temperature alloy steels. Titanium's resistance to corrosion is excellent.

These properties, especially the high strength-to-weight ratio, make titanium a desirable metal for use in aircraft, naval and ordnance applications, to mention only a few. But titanium has two big drawbacks. First difficulty is titanium production or, rather, the lack of it. Total output of titanium in 1951 was only 700 tons, and commercial alloys cost about $25 per pound. Recent improvements in induction and arc-melting of the metal, plus increases in production capacity, will soon change this picture, although no phenomenal expansion is planned.

Processing is the second bugaboo in the use of titanium. Although titanium can be machined as easily as austenitic stainless steel, special techniques are needed for hot forging or rolling because of titanium's tendency to "get" atmospheric gases at high temperatures. Cold forming is also difficult. Consequently most titanium parts have been machined from solid stock, and the resulting waste of material and increased cost have curtailed use of the metal to experimental components.

Recently, however, a number of companies have indicated interest in the potentially lucrative commercial processing of titanium, despite the difficulties. One, for example, is turning out titanium alloy bar forgings; another, titanium alloy strip. A third new development is a rotary draw former announced by the Cyril Bath Co. for stretch-forming titanium sheet. All of these developments, plus many more that will probably be forthcoming as research in manufacturing methods increases, should add impetus to use of the metal.

Minor Matters: Among the more interesting byproducts of the ever-changing materials situation is an amendment to the NPA's Rubber Order M-2. Among other things, this newest of official pronouncements formally lifts all restrictions on the manufacture of white sidewall tires. Previously, only black tires were allowed, although white sidewalls could be added on with paint.

Design Abstracts

(*Continued from Page 172*)

By positioning joints so that the poor fit-up is placed on the vertical leg of the fillet welds, root openings up to 1/16-inch on ¼-inch plate are easily welded without arcing through the joint. Use of the semiautomatic or automatic welding heads which allow high welding speeds, produces considerably less distortion than that obtained by manual processes and also practically eliminates the weld-cleaning operation.

In the structural design, *Fig.* 3, the outer corners of the unit are produced with press operations and the internal joints are produced by lapping plates to provide for fillet welds. Minimum demands are placed not only on welding and fit-up operations but also on fabrication operation, thus effecting maximum economy.

Automatic welding can be easily adapted to job-shop production if designs are produced where the major share of the welding can be applied from one side. In most cases, steel or copper back-up bars, as well as glass fiber sleeving or tape can be held in position by screw clamps, air clamps or permanent magnets to accomplish complete penetration of joints.

Shop Application: The design approach, previously discussed, will enhance the use of universally applied jigging. For manipulating this jigging and the product being

Fig. 5—Platform type of positioner for welding intricate assemblies. Hinged joints provide for expansion and contraction and a motorized table permits positioning adjustments

produced, properly designed welding positioners, power turning rolls and welding-head manipulators can be utilized as standard equipment. The manipulators can be used to advantage to decrease initial tooling cost, to provide for application to several jigs and to produce the proper environment to meet the characteristics of the welding processes and methods.

A flexible and universally applied welding-head manipulator and positioner is shown in *Fig.* 4. In this illustration a motor case is being welded and joints produced are longitudinal and lateral to the welding-head manipulator. To produce lateral joints, the boom on which the welding head is mounted is moved through the column of the welding-head manipulator so that the welding head traverses the joint. For longitudinal joints the welding-head manipulator is propelled along the track. In both instances the welding positioner places joints for proper control of the arc and arc pool. Circumferential welds can also be made with this equipment by rotating the assembly by means of the welding positioner. Further, inside and outside joints can be welded where there is sufficient provision to engage the welding head. In cases where the amount of welding warrants application of a flexible electrode extension, joints several feet long can be made through openings

Fig. 6—Welding positioner for use in semiautomatic welding. Work is rotated past the operator. Three previously welded assemblies are shown in the foreground

as small as 4 or 5 inches in diameter.

A platform type of positioner is shown in *Fig.* 5. The platform is mounted between a motorized headstock and idler tailstock. The hinged joint between the platform and pedestals mounted on the headstock and tailstock provides for expansion and contraction to maintain alignment. The platform is provided with a motorized rotating table and, consequently, practically any intricate assembly can be completely positioned. This unit operating with an automatic welding-head manipulator, *Fig.* 4, could be applied to any irregular assembly for speedy universal application.

Simple semiautomatic welding operations can be produced by merely using a welding positioner to rotate the work past an operator. As shown in *Fig.* 6, the operator supports the semiautomatic gun to complete the weld. Three samples of completely welded fittings are shown in the foreground.

In the job shop, tooling has a substantial effect on the cost and success of any weldment. Consequently, tooling must not only produce a fast and accurate setup, but also must be suitable for modification by removing or adding elements to accommodate a full range of sizes and types of weldments being produced.

From a paper entitled, "Product Design for Welding," presented at the Thirty-Second Annual Meeting of the American Welding Society in Detroit, Mich., Oct., 1951.

Modell Concept of Wear

By T. L. Oberle

Research Dept.
Caterpillar Tractor Co.
Peoria, Ill.

PAST efforts to reduce wear have always been aimed at increased strength and hardness of materials. This approach has been quite successful, but engineers are more and more frequently faced with ceiling limitations of maximum hardness which may be obtained. Additional gains are possible in the direction of minimizing the build-up of loads on metal surfaces. Reduced surface loads are obtained by reducing the elastic

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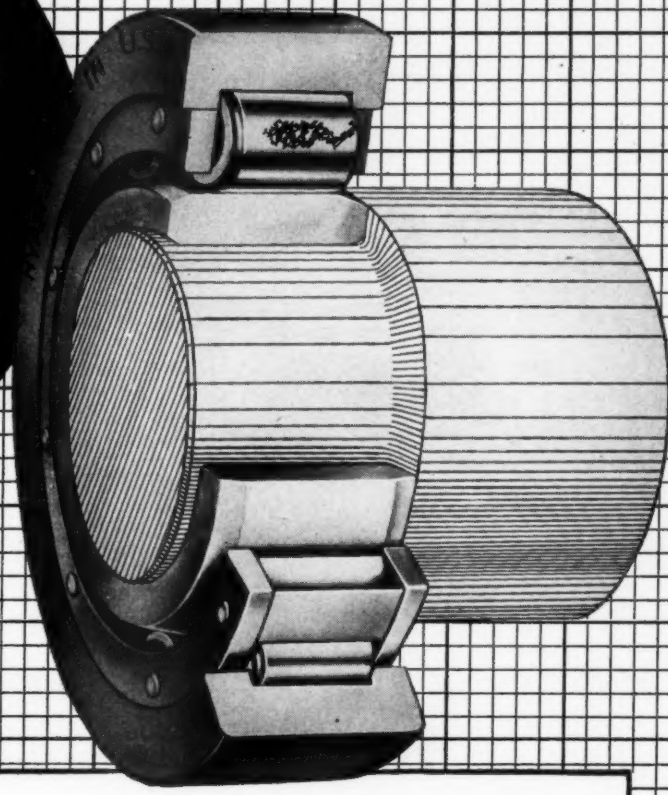

THE simplest way to mount bearing inner races is by press fitting. Hyatt Hy-Load Roller Bearings are designed and constructed to permit relatively heavy press or shrink fits of races—fits sufficient to retain races properly without resorting to auxiliary devices such as snap rings, lock nuts or keys.

This is possible because Hyatt Hy-Load races are made from carburizing type steels, carburized and heat treated to provide hard, wear resistant, case-hardened surfaces with tough ductile cores. A hard surfaced race with a ductile core permits heavier press fits than a through hardened race.

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For more information about this and many other features of Hyatt Hy-Load Roller Bearings, write for Catalog 547. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

modulus of a material. The combination of high hardness with low modulus should result in superior wear resistant materials for the future.

High hardness, sought after to increase wear resistance, actually increases the amount of elastic deformation that can be tolerated by a steel. Since the amount of elastic deformation may be important in wear phenomena, additional means of increasing it should also be explored. An important method of altering the total elastic deflection of materials is through control of the elastic modulus of materials.

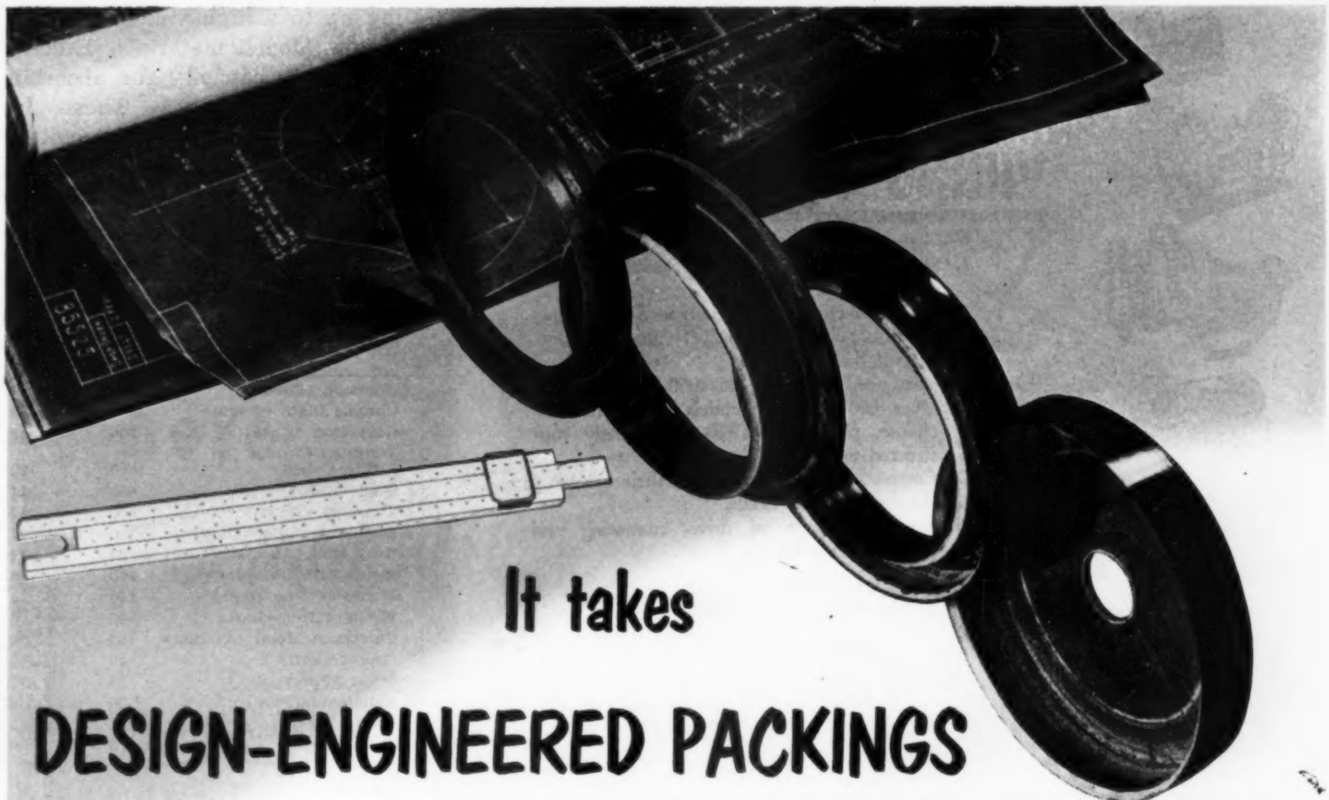
The elastic modulus of a material is the ratio of stress to strain. Stress-strain curves for high modulus metals have a steep slope since a high stress causes relatively little elastic strain. For low modulus metals the curves have a shallow slope, showing that a small stress results in a relatively large elastic strain.

Large amounts of elastic deflection may be achieved by the selection of materials which have high strength and low modulus. This desirable combination of properties does not occur commonly in metals, but both the elastic limit and the elastic modulus of metals are controllable within limits. We thus have for the future considerable latitude in increasing the total elastic deflection of which materials are capable.

"Modell" Defined

A convenient value for the total elastic deflection which is possible for a material may be obtained by dividing the Brinell hardness of a metal by its elastic modulus. The ratio of Brinell hardness to elastic modulus, multiplied by 10^6, will be referred to as "Modell." Materials are listed in TABLE 1 in order of decreasing Modell.

By its definition, Modell gives an indication of the depth of penetration that a metal can tolerate without exceeding its elastic limit. Chromium plate will recover elastically from more than 100 times the amount of deformation that will cause tin to yield plastically. Materials of high Modell behave like a spring, absorbing energy and preventing loads from build-



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ing up to a high value.

Low Modell materials, Table 1, have little capacity for absorbing energy elastically. These low Modell materials are most suitable for use as bearings. Low melting temperature metals such as lead or tin seem to be essential to every commercially acceptable bearing composition.

Table 1—Modell Values for Various Materials

Material	Brinell Hardness	Modell
Alundum (Bonded)	2000	143
Chrome Plate (Bright)	1000	83
Gray Iron (Hard)	500	33
Tungsten Carbide (9% Cobalt)	1800	22
Steel (Hard)	600	21
Titanium (Hard)	300	17
Aluminum Alloy (Hard)	120	11
Gray Iron (As cast)	150	10
Structural Steel (Soft)	150	5
Malleable Iron (Soft)	125	5
Wrought Iron (Soft)	100	3.5
Chromium Metal (As cast)	125	3.5
Copper (Soft)	40	2.5
Silver (Pure)	25	2.3
Aluminum (Pure)	20	2.0
Lead (Pure)	4	2.0
Tin (Pure)	4	0.7

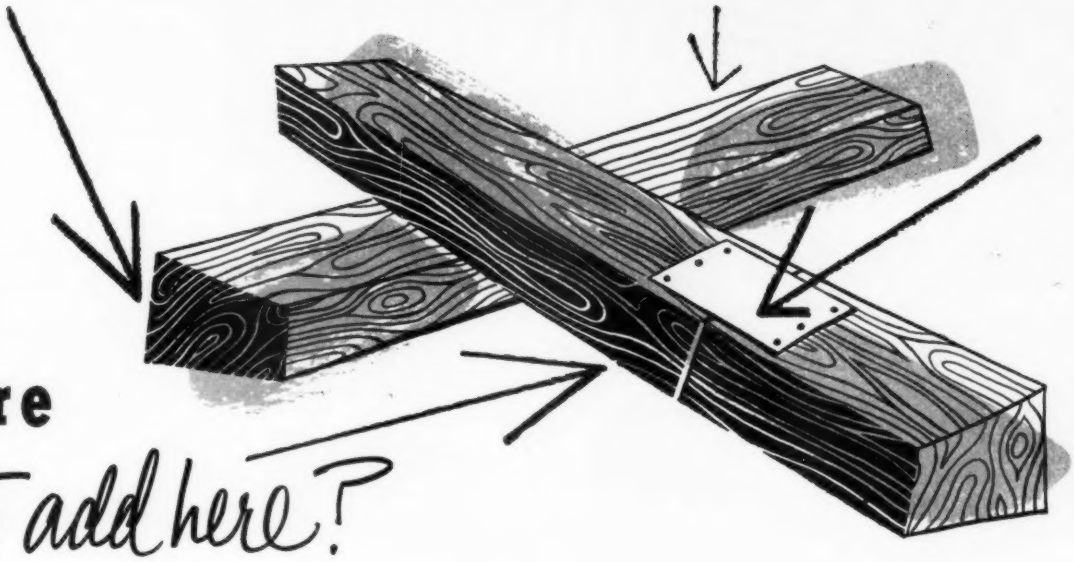
The elastic modulus of metals is influenced by melting temperature and atomic volume. The elastic modulus of low melting metals tends to be low, and the elastic modulus of high melting metals tends to be high. There is a tendency for elastic modulus to decrease as the atomic volume increases.

In addition to these inherent factors which determine the general level of elastic modulus, some metals are susceptible to variations in elastic modulus that may be controlled within limits during the fabricating, casting, or heat treating stages of manufacture. Some controllable factors that may alter the elastic modulus of metals are heat treatment, interruptions, and anisotropy.

The aging of some age-hardenable alloys may result in a small increase in elastic modulus. Most metals and alloys, such as steels, have virtually no change made in their elastic modulus by heat treatment of any kind.

Interruptions to metal continuity may take form as cracks, gas cavities, or voids of any kind. The graphite present in gray iron is included in this classification be-

why cut here to add here?



Doesn't make much sense, does it? Yet it happens all the time . . . particularly with inferior steel castings. Sure, the initial cost is likely to be less, but from there on you start piling it up again. Unnecessary handling . . . excessive machining time and always the possibility of finding a defect after part of your machining is done.

Sivyer customers have learned that Sivyer finish . . . clean core holes, accuracy of dimensions, freedom from distortion, absence of waste metal . . . means lower cost conversion, extra dependability.

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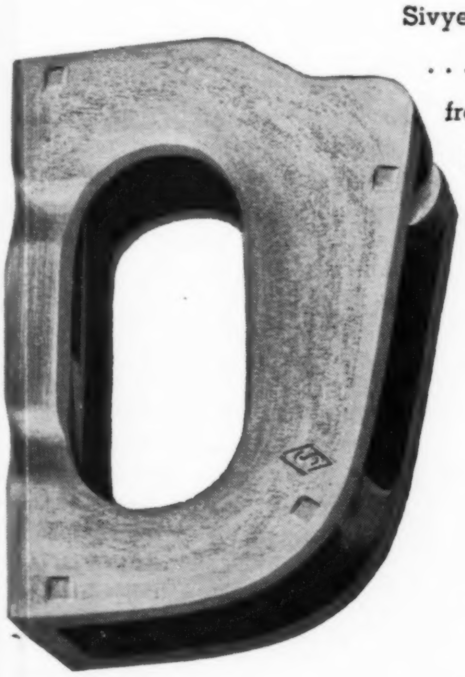

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cause its low modulus apparently permits it to behave somewhat as though the enclosure around it is empty. The elastic modulus of metals decreases in direct proportion to the volume of spherical type voids. Elongated interruptions, such as flakes or cracks, decrease the elastic modulus of a metal in a direction transverse to the long dimension of the discontinuity.

Anisotropic single crystals exhibit different properties in one crystallographic direction than another. The elastic modulus of a single crystal of iron is 19,200,000 psi in a direction parallel to any one of the three major axes. As the direction of load is tilted away from these major axes, the elastic modulus increases until a maximum value of 41,240,000 psi is obtained when the load acts along the space diagonal between the three axes. Polycrystalline metals, under certain conditions, will give up their random crystalline arrangement and assume a preferred orientation. Such preferred orientations, as developed during cold working or plating operations, have not as yet been exploited for maximum control of the elastic modulus of metal surfaces that is possible.

Criterion of Wear

The success of gray iron in resisting engine wear is attributed by some engineers to the lubricating qualities of the graphite present. Yet, malleable iron containing the same amount of graphite as gray iron cannot be substituted successfully for gray iron in many engine parts.

The difference in Modell values alone is sufficient to account for superior running qualities of gray iron. Gray irons containing finely dispersed dendritic graphite may have elastic modulus values as high as malleable iron, so that more knowledge than just that the iron was cast gray is necessary to judge the suitability of the material for frictional applications.

Wear increasing as hardness increases is contrary to expectation. This reversal of the usual trend is the result of the sharply increasing modulus that occurs simul-

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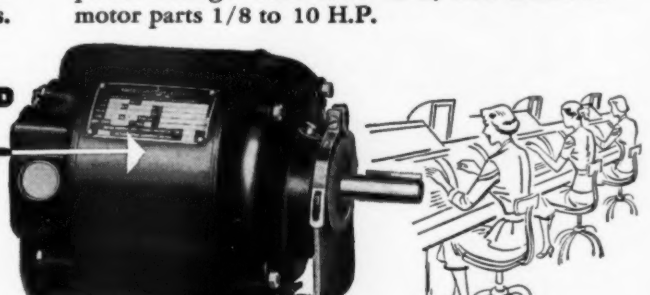

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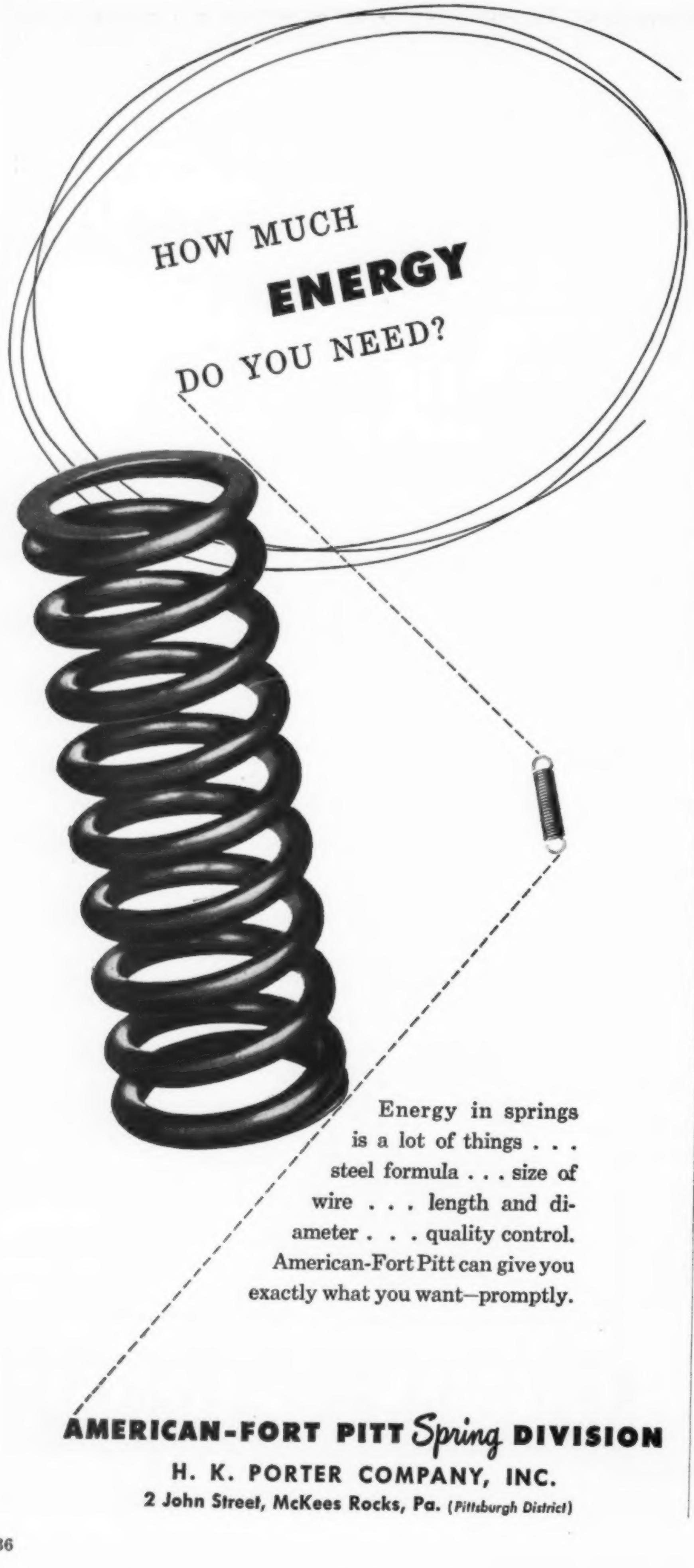

taneously with the hardness increase. For most materials, the elastic modulus is unchanged during hardening and its influence is not felt. Data from various sources indicate that for wear applications, gray iron should be cast with coarse graphite flakes and hardened by heat treatment to produce maximum Modell, rather than obtain high hardness in an as-cast, high-strength iron with resultant high elastic modulus.

Low Modulus Aids Wear

Outstanding wear results have been observed with the use of some materials normally considered abrasive. These data show that all surface plates are worn less by a low elastic modulus gray iron than by a hardened steel and that the low elastic modulus gray iron itself wears less than hardened steel. Also, the data show that high Modell surface plates resist wearing much more than low Modell materials.

Tests have shown Al_2O_3 cylinder liners to possess excellent wear resistance. In addition to freedom from liner wear, the wear rate of piston rings is greatly reduced. With economical methods of manufacture of Al_2O_3 wearing surfaces, this material may become as commonplace for engine and tractor parts as semi-precious jewel mountings have for all types of timepieces.

Ceramics Show Promise

Powder metallurgy techniques permit combining of extremely hard oxides, carbides, nitrides, etc. with a suitable binder to yield an aggregate of low elastic modulus. Current work on ceramic-metallic materials is centered around high temperature applications in jet engines. A bright future for ceramic-metallic materials exists in the field of wear applications for such parts as face seals and valve guides.

As a general rule, the difficulties of machining increase with the hardness of the work. However, if the hardness is to be kept low for easy machining, the Modell value or wear resistance may be increased by lowering the elastic modulus of the material. Lower-

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Terminal Board (left) for continuous train control and relay pusher (right). Both pieces are made from Synthane laminated plastics for General Railway Signal Co., Rochester, N. Y.

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ing elastic modulus improves resistance to wear and at the same time may improve machinability. High Modell materials, if gray iron is any criterion, machine more readily than low Modell materials of the same hardness. A considerable economic advantage will result from developing wear resistant materials of low hardness. For gray iron, this will involve some degree of control of graphite flake size and orientation. Maximum wear resistance will result if some of the graphite flakes near the surface can be aligned parallel to the loaded surface.

From a paper entitled, "Hardness, Elastic Modulus, and Wear of Metals," presented at the SAE Annual Meeting in 1952.

Protective Neoprene Coatings

By L. S. Bake
*E. I. du Pont de Nemours & Co. Inc.
Deepwater, N. J.*

NEOPRENE is now produced in a form which makes it suitable for protective coatings on the exterior of tanks, process equipment, structural steel, pipelines and the like. The new material is not intended, like the older linings, for direct immersion in corrosive chemicals, but for protection against splash, spill or corrosive fumes and atmospheres.

Neoprene protective coatings are the result of two developments: first, a slightly modified neoprene polymer which, before vulcanization, produces solvent solutions of low viscosity per unit of solids content, and second, accelerators which will cure this polymer at room temperature. Main ingredients of the coating are an aromatic solvent, carbon black, neoprene and a separately added accelerator. It dries by solvent evaporation and cures by polymerization.

Advantages: The film itself has neoprene's excellent resistance to acids, alkalis, oils, most hydrocarbons, and sunlight and weather. It is tough and rubbery, and its resilient qualities are inherent—not the product of plasticizers which may volatilize or leach out. Solids

content is 60-70 per cent, giving a thick film per coat. The coating cures at room temperature in 24 to 48 hours with addition of an accelerator at the time of use. A second coat may be applied two or three hours after the first coat without danger of brushing up the first. A fresh coat bonds well even to a fully cured prior coat.

Disadvantages: It is a two-part system; the user must stir a few ounces of accelerator into each gallon of material just before application. After acceleration, pot life is 12 to 36 hours, depending on amount of accelerator used. Befor acceleration, shelf life is at least a year. To be sure of good adhesion, a surface must be thoroughly wire-brushed or sandblasted and a coat of primer applied (chlorinated rubber is the recommended primer). Colors other than black can be had only at the expense of some chemical and abrasion resistance; light, pastel colors are not practical because neoprene darkens somewhat on aging.

From a talk entitled, "Neoprene Maintenance Coating," presented before the St. Louis section of National Association of Corrosion Engineers in January, 1952.

Slide Rules of Tomorrow

By W. C. Schaffer

Ram Jet Div.
Wright Aeronautical Corp.
Wood-Ridge, N. J.

ANALOGS are the slide rules of tomorrow. Even today, conventional desk calculators are inadequate for the solution of many problems encountered in engineering and considerable use is being made of automatic high-speed computing machines. It is no longer sufficient to know just the steady-state solution; engineers have to know what goes on during the transient.

Analogs, like other computing machines, *can't* think, but they can do involved, lengthy calculations in amazingly short time. Furthermore, machines can cope with nonlinearities that defy other analytical methods. Thus, these devices do not replace the human operator. Rather, by supplying the engineer

with a means for accomplishing long, monotonous calculations, the machines release brain power for consideration of problems which hitherto have required such long solution times that any attempt was believed impractical.

For one type of analog computer, voltages are used to represent the variables and are measured on oscilloscopes as plots against time or each other. The computing voltages are interconnected so as to vary in magnitude and phase in the same manner as their physical counterparts. The power input required is 110-volt, 60 cycle current. A computing period is 1/240 second, obtained by using a square wave disturbance derived as one fourth of the 60-cycle current. This computing speed is truly remarkable. Hours of computation are reduced to less than 0.005-second and are repeated at a rate of 240 cycles per second. Thus, once a computing circuit is set up, answers are available, and the effects on the solution of desired parameter variations are immediately apparent.

Greater flexibility is provided by utilization of analog components such that each unit provides one mathematical relationship between input and output voltages. Thus, an adder unit combines four voltages to produce an output voltage which is the algebraic sum of the inputs and a coefficient unit provides an output voltage which is the product of the input and a factor determined by the dial setting.

Special Units Available

More involved units are those which multiply two varying voltages, integrate, differentiate, and square. In fact, one unit, called a "function fitter", can be adjusted to approximate any relationship between two variables. Trigonometric relationships can be represented as well as Fourier series. Special cases of the functions of two independent variables can be handled with present equipment. The general case of the function of the two independent variables is presently being investigated with considerable promise of success.

Hysteresis, dead zone, and bounding are characteristics of physical systems that have plagued the mathematical investigator and which have sometimes been neglected in otherwise elaborate computations. However, such components for the analog computer are available and are in use. Engineers concerned with the development of physical devices will appreciate the convenience afforded by these nonlinear computing components.

Analog equipment has been used for investigations of stress, vibration, thermal, and trajectory problems. The analog techniques currently being developed are demonstrating great utility and promise even more for the future.

From a paper entitled, "Application of Analog Techniques to Control Design for Aircraft Engines," presented at the SAE Annual Meeting in Detroit, Mich., Jan., 1952.

Radioisotopes for Research

By George G. Manov
Atomic Energy Commission
Oak Ridge, Tenn.

As a result of the development of the nuclear reactor, a large number of man-made radioisotopes have become available. The overall program of the Atomic Energy Commission in this field is administered by the Isotopes Division at Oak Ridge, Tennessee, and involves responsibility for the distribution of radioactive materials to qualified workers in science, medicine, industry and education. Approximately 150 radioisotopes ranging alphabetically from antimony to zirconium are offered, and in addition, special irradiation services can be arranged.

Radioisotopes have proved to be valuable because of certain unique properties they possess: specificity, sensitivity and versatility. They can be used to "tag" atoms or molecules for identification from identical but inactive species. The sensitivity of the radioisotope technique is several orders of magnitude greater than conventional physical or chemical methods. A radioelement such as carbon-14, for example, can be incorporated into methane, heavier hydrocarbons, fatty acids, phenols, etc. The versatility of the radioisotope tech-

nique is therefore appealing.

Because of the over-lapping of research fields, it is not practicable to make a sharp division between the application of radioisotopes to industry as a whole and to a specific field such as petroleum or automotive research. For example, new information obtained by a steel chemist primarily to elucidate the phase-rule diagram for an iron-manganese alloy may be translated into improved corrsion-resistance for pipes used as casings for oil wells, or for obtaining improved shock resistance in the bumper of an automobile.

Broadly speaking, radioisotopes can be used in two ways: (1) as sources of radiation only, and (2) as tracers to follow a particular process or flow stream. In the space of the last three years the accomplishments have been numerous and particularly illustrative of the power of this new tool.

Wear Detected Easily

Prior to World War II, cyclotron-produced radioisotopes were used to study the wear of piston rings. Recently, the study has been extended and widely applied. Conventional piston rings are made radioactive by subjecting them to neutron bombardment in the Oak Ridge reactor. One atom of iron in approximately one billion is converted from stable iron to iron-59. The active rings are fitted to the pistons using proper shielding and monitoring techniques, the engine is assembled, the lubricating oil is added, and the motor is started. The sensitivity of the radioisotope method is so high that the wear of the rings can be detected in the first few minutes of running time.

The experiments were made primarily to determine engine wear as a function of the type of lubricating oil used, and have led to the production of oils that, according to the refiner, will stand up better under severe service conditions. Alternatively, the same experimental setup can be used to determine the effect of octane number, sulfur content, load factor, water jacket temperature, etc., on the rate of wear. It should be noted that it is not necessary to dismantle the engine and that both the rate and the total wear can be measured readily.

Although these experiments were made in the search for a better lubricant, it is immediately evident that research groups might equally well study the effect of variations in the chemical composition or physical properties of the piston ring, the durability of inlet and exhaust valves, the scavenging of the exhaust gases, the depositions of iron (or of lead) along the exhaust manifold, the rate of wear of water pumps, the corrosion of radiators by water and by various antifreeze mixtures, etc.

Radioisotopes generally can be used wherever it is necessary to detect the transfer of materials from one surface to another, even when both surfaces are chemically identical, and where the amounts involved are as little as 10^{-9} to 10^{-12} grams.

From a paper entitled, "The Availability of Radioisotopes and Their Application to Petroleum and Automotive Research," presented at the SAE National Fuels & Lubricants Meeting in 1951.

Designing Engine Mountings

By T. H. Peirce

H. A. King Co.
Detroit, Mich.

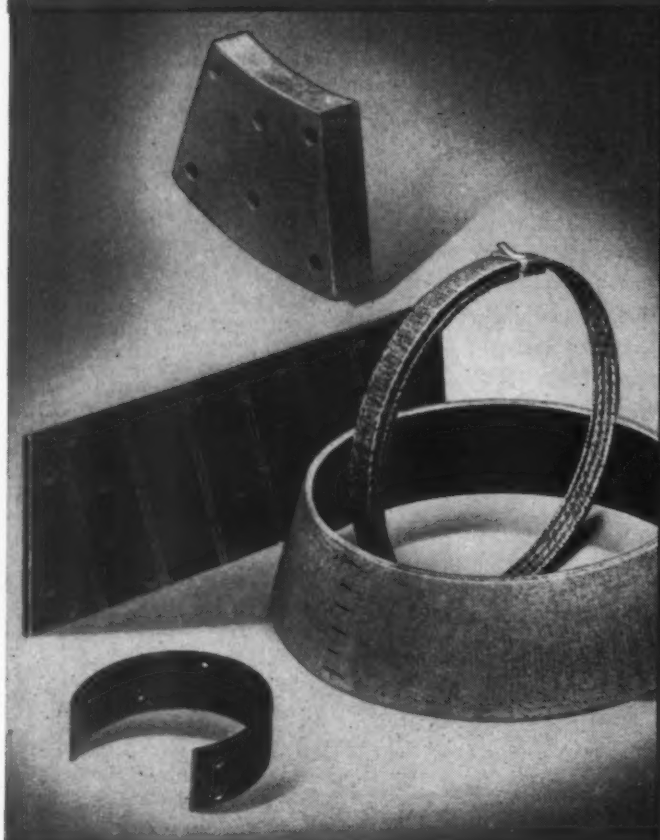
POWER plant vibration can be caused by engine roughness, torsional vibration, out of balance, reciprocating forces, combustion roughness and torque reactions. When flexible rubber mountings are used to absorb vibration, the mountings function like springs. With the engine supported on rubber mountings, its mass can be called a sprung load. This load causes a static deflection of the rubber. With the same mountings and the engine in operation, the rubber mountings will flex. This on-and-off loading of the rubber is termed the dynamic condition.

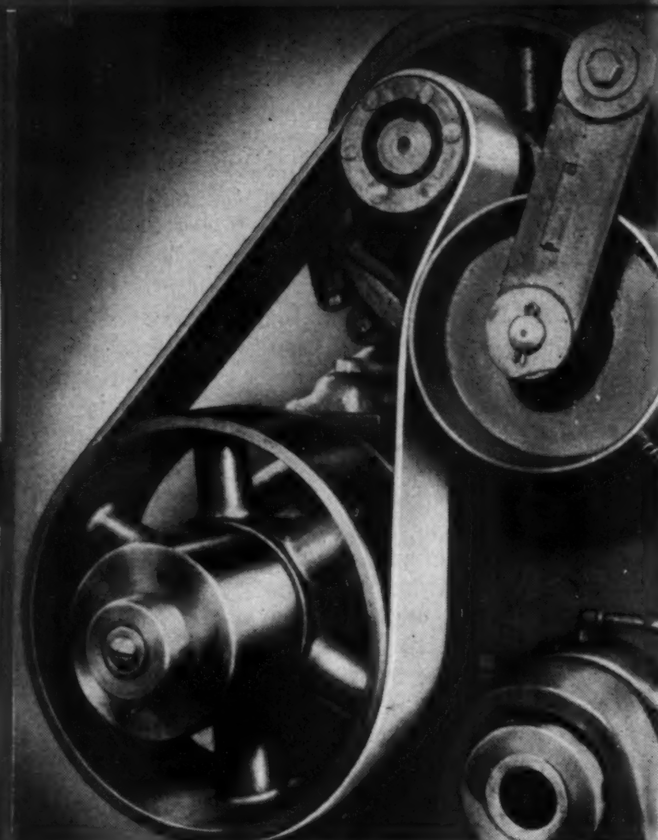
When static deflections are large, the natural frequency of the system is low. When the opposite of this condition occurs, the frequency is high. Engines mounted on resilient rubber mountings will have a natural frequency which can be determined by means of calculation or from charts when deflection and load factors are

(*Continued on Page* 248)

RAYBESTOS-MANHATTAN ENGINEERS OFFER HELPFUL SERVICE ON ASBESTOS AND RUBBER PRODUCTS

R/M



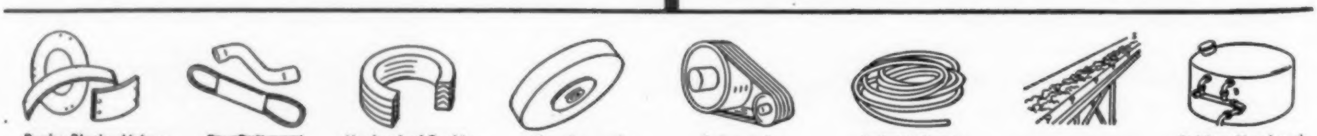


Friction Materials

The wide variety of R/M friction materials made for American machine designers is well illustrated above. R/M makes brake linings, brake blocks, brake segments, clutch facings, bands, cones and many special shapes. These R/M "Frictions" are made of sintered metal, molded or woven asbestos. Each is unique in its design, size, composition, friction and engagement characteristics; and in its suitability for a particular type of service. In hundreds of thousands of machines, large and small, and in millions of automobiles, trucks and buses, as well as tractors and other types of construction and agricultural equipment, R/M friction materials assure perfect "Stop and Go" performance.

Mechanical Rubber Products

Raybestos - Manhattan has continually kept ahead of changing demands in the development of mechanical rubber products. The Condor Whipcord Endless Belt is an example of industrial foresight at R/M. This transmission belt has been known to outlast from 2 to 10 ordinary type endless belts on many drives. Made from strong de-stretched cords, endless wound and embedded in rubber, it is a highly flexible belt, unaffected by temperature changes. The exclusive Manhattan Extensible-Tip prevents cover splice separation by extending the joint stress over a wide area. The same R/M ingenuity in engineering applies to hose, conveyor and V-belts, molded rubber products.



SPECIALISTS IN ASBESTOS, RUBBER, AND SINTERED

(Continued from Page 245)

known.

With engines supported on rubber mountings designed and calculated for maximum allowable deflection—and properly located with respect to the engine and supporting members—the results should indicate that the natural frequency will be lower than the forced frequency. When annoying vibration must be practically eliminated, relatively large static deflections in the rubber are required.

All mountings are governed by the limits which can be tolerated insofar as engine movement is concerned. It is very easy to obtain operating smoothness at the expense of excessive engine movement and without any thought of directional control which is so important when a mechanical transmission is used. A compromise on engine movement and operational smoothness is part of the engine mounting problem.

Each new engine and chassis installation problem differs from its predecessors in many respects where, for instance, changes have been made in the chassis mounting brackets and cross members. In such instances everyone has the urge to use mountings that are available, or mountings where tooling is already in existence. Only in rare instances has such practice and procedure resulted in acceptable engine mounting performance. In the majority of known cases where this procedure was used the results were such that the performance could have been improved.

Resonance Not Critical

Power plants, when mounted on rubber, pass through resonant frequency when started or stopped. However, this factor can be neglected in design because resonance is passed rapidly; before too high an amplitude is attained.

Particular care must be exercised in the design and location of engine mountings so as to provide all possible room for servicing or for the complete removal of the power plant. Mountings should be designed so that any frame weave or bending will not impose abnormal loads on engine mounting brackets, or cause damage to the

related parts in the assembly, such as flywheel housing, clutch housing or transmission case.

The general procedure for determining the location of the mountings for both gasoline and diesel engines is relatively the same, as the principal factors are determined by either experimental test or analysis. In this respect the following basic information will be required before any extensive mounting design is initiated:

1. Power plant weight with all accessories, clutch, transmission, or torque converter
2. Location of center of gravity
3. Maximum torque
4. Minimum idle speed
5. Compression ratio

The various factors as indicated are usually available, with the exception of the center of gravity location. This can be determined quickly and without considerable expense by hanging the power plant in two positions, first with brackets attached to the cylinder head, and second by turning the engine on its side and using brackets on the cylinder head and the bottom face of the crankcase; this procedure requires the use of a plumb bob and level.

Detailed Study Required

In all mounting applications the overall problem must be studied in detail so that all factors are known and determined before the project is released for design. In this respect the following points are important:

1. Mounting accessibility
2. Accessibility for easy removal of power plant from chassis
3. Determination of proper location for engine mountings
4. Determine location and make provision for flexible fuel lines
5. Proper provision to be made for engine controls
6. Flexible connections for cooling system
7. Engine operating temperature
8. Provision for engine stability when in operation, for all conceivable road surfaces and at all operating speeds

When this information is available, the size and location of the engine mountings can be determined. The requirements for chassis cross members or available engine mounting locations will de-

termine the number of mountings. In general, three or four mountings are used. With the location of the mountings determined, the next factor to be considered is the type of mounting to be used, i.e., shear or compression, on the front or rear of the engine. If shear mountings are required because of assembly problems, the mounting will require bonding of the rubber to metals. If compression mountings can be used, the parts may be molded without metals and should result in lower mounting cost.

After determination of mounting location, the design of the part is made. The analysis will help determine the rubber characteristics required. The physical properties of the rubber used are determined by the engine characteristics, the mounting design and stability requirements.

Tests Indicate Changes

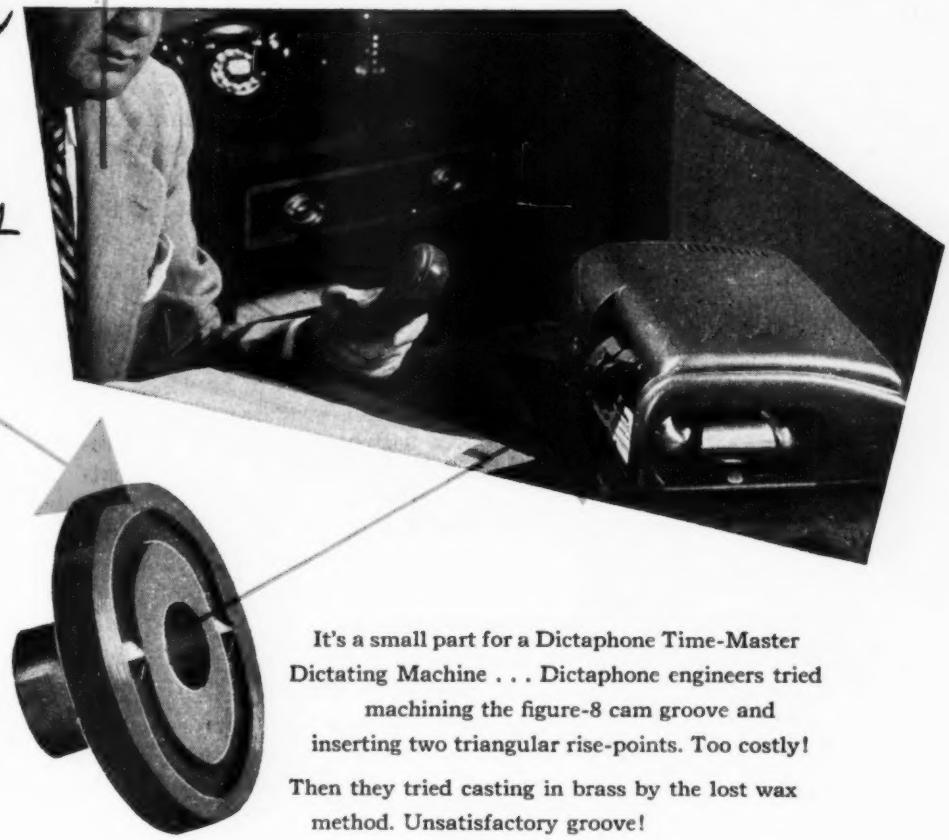
When experimental tests are completed with the mountings as designed, the results may indicate that changes in the rubber compound or hysteresis are required to attain smoother engine operation. It is possible that slight changes in the location of the mounting may be desirable to control engine movement and obtain better performance and stability.

As a rule, the combined load of the engine plus any dynamic loads while in operation will determine the adhesion or loading areas. The load and engine characteristics will determine the thickness and other overall mounting dimensions, and the compound required. The frequency of the suspended system can be changed by altering the modulus of the rubber compound.

SAE and ASTM specifications are used for the manufacturing and processing of rubber parts now in production. Shear load deflection limits as published in various rubber company handbooks along with other pertinent data should be the governing factor in mounting designs after the location and arrangement of the mountings has been decided.

From a paper entitled, "Engine Mountings" presented at the SAE National Transportation Meeting in **1951.**

How would you produce this part?



The part illustrated was made by The Wel-Met Co., Kent, Ohio

It's a small part for a Dictaphone Time-Master Dictating Machine . . . Dictaphone engineers tried machining the figure-8 cam groove and inserting two triangular rise-points. Too costly!

Then they tried casting in brass by the lost wax method. Unsatisfactory groove!

The irregular contours, changing radii, the rise-points in the cam groove, pointed to powder metallurgy as the solution of these complex difficulties.

The precision of this method is such that machining or finishing operations are often eliminated.

Tolerances as low as ±.003" are easily held; on some parts as close as ±.001". Production rates run as high as 50,000 per hour per press.

The pressing and sintering processes create novel alloys, as of copper with steel or copper with carbon . . . permit the combining of oil and metal to give long self-lubricating bearing life . . . cut costs of many parts to a fraction of what they would be by machining, casting, forging, stamping.

Stokes engineers . . . designers and builders of the presses on which powder metal parts are made . . . will gladly consult with you on the suitability of your parts for powder metal production . . . or on their re-design to adapt them to this money-saving method.

STOKES MAKES
Plastics Molding Presses,
Industrial Tabletting
and Powder Metal Presses,
Pharmaceutical Equipment,
Vacuum Processing Equipment,
High Vacuum Pumps and Gages,
Special Machinery

STOKES

F. J. STOKES MACHINE COMPANY, 5586 TABOR ROAD, PHILADELPHIA 20, PA.

News

OF MANUFACTURERS

PLANS are now being made for the construction of a project costing approximately $15,000,000 which will increase facilities of the Springfield, Ill., Tractor Div. of **Allis-Chalmers Mfg. Co.,** Milwaukee. More than 300,000 sq ft of manufacturing space, as well as the necessary machine tools for increased production of crawler tractors, motor graders, and repair parts will be included in the program. The addition will be located east of the main building of the division's plant No. 1 in Springfield. It is expected that construction will begin before the middle of summer.

◆

Rockwell Mfg. Co., Pittsburgh, recently announced the acquisition of the **Deluxe Saw & Tool Co.** and the **Karbide King Tool Corp.,** with plants in Chicago and High Point, N. C.

◆

A plan of merger has been approved by the stockholders of **American Gas Accumulator Co.,** Elizabeth, N. J., and **Elastic Stop Nut Corp. of America,** Union, N. J. Business of AGA will be carried on as a division of Elastic. These two companies have been closely associated for many years.

◆

Plans for expanding facilities for manufacturing machine tools have been announced by **The Cross Co.,** Detroit. Over 33,000 sq ft of floor space have been added by the purchase of a building across the street from the company's main plant. Large parts manufacturing will be concentrated at the original factory; small parts, at another plant now occupied by Cross; and final assembly, in the new building.

◆

Westinghouse Electric Corp. will build the complete power plant for the world's first atomic-powered submarine, the U. S. S. Nautilus, including both the nuclear reactor

and the associated propulsion equipment. This information was revealed in the company's annual report, which also disclosed that Westinghouse will build the most powerful machinery yet designed for ship propulsion, the turbine and gear assembly for the nation's newest aircraft carrier, the U. S. S. Forrestal.

♦

Ground has been broken for a $600,000 addition to the **C. H. Wheeler Mfg. Co.** plant in Philadelphia. The new building will be equipped with 30-ton cranes. A new centrifugal pump test laboratory is being provided with a 400,000-gal pit with venturis, weirs and dynamometers, for testing pumps up to 110,000 gpm.

♦

The opening of a new web coating research and development laboratory has been announced by **Industrial Ovens Inc.,** Cleveland. The laboratory is equipped with a complete pilot plant coating unit which can process textiles, papers, films and foils through all methods of coating and impregnating. The unit automatically controls processing velocity, temperature, time, coating thickness and embossing pressure.

♦

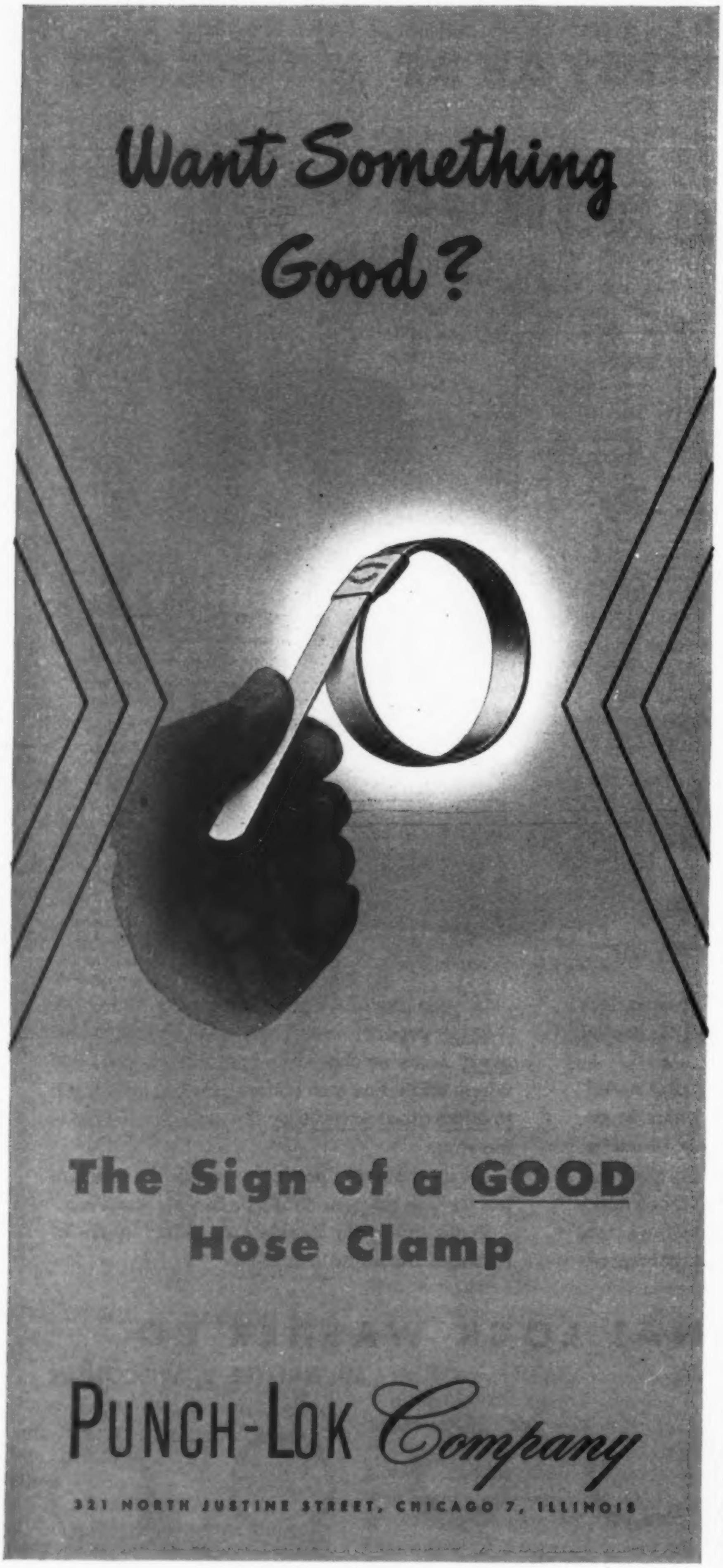
Kropp Forge Co., Chicago, has announced that the name of its wholly owned subsidiary, A. C. Woods & Co., Rockford, Ill., has been changed to **Kropp Steel Co.** The subsidiary is engaged in the steel fabricating and weldment business.

♦

Directors of **Ferro Corp.,** Cleveland, have authorized acquisition of a 50 per cent interest in **The Wel-Met Co.,** specialists in powder metallurgy at Kent, O., and Salem, Ind. A new factory built by Wel-Met in Salem last year will permit tripling of production.

♦

The plant and property formerly owned by the **Jumbo Steel Co.** in Azusa, Calif., has been purchased by **American Brake Shoe Co.,** New York. The property consists of approximately 5 acres of land and several buildings. The American Forge Div. of Brake Shoe will use



the plant to start a West Coast steel forging operation. Machinery for upset and press forgings will be installed, and it is expected that operations will begin about the middle of this year.

•

Aluminum Co. of America and **Bohn Aluminum and Brass Corp.** have been licensed to use the Al-Fin process for the molecular bonding of aluminum to iron or steel. Announcement of the licensing of the two firms was made by the Al-Fin Div. of **Fairchild Engine and Airplane Corp.,** Farmingdale, L. I., N. Y.

•

Inasmuch as the company manufactures such products as air and gas compressors, diesel and gas engines, air conditioning and refrigeration equipment, electric motors, V-belt transmission drives, construction equipment, etc., in addition to pumps, the name of Worthington Pump and Machinery Corp., Harrison, N. J., has been changed to **Worthington Corp.**

•

Barber-Colman Co., Rockford, Ill., will purchase the principal assets of **Wheelco Instruments Co.,** Chicago. Present plans call for the continuation of current operations in Chicago until such time as manufacturing facilities can be gradually transferred to Rockford.

•

The name of Seattle Chain & Mfg. Co., Seattle, Wash., has been changed to **Round Seattle Chain Corp.** This company was acquired by the Round group in 1920.

•

Radio Receptor Co. Inc., Brooklyn, N. Y., has been licensed to manufacture germanium transistors and diodes, according to an agreement concluded recently with **Western Electric Co.**

•

An agreement for the formation of a company to manufacture plastic materials in Japan has been announced by **Dow Chemical International Ltd.,** a subsidiary of **The Dow Chemical Co.,** Midland, Mich. The new corporation, to be known as **Asahi-Dow Ltd.,** will be an associated company of Dow International and The Asahi Chemical In-

No. 2 IN A SERIES

IT'S NOT HOW MUCH YOU PAY TO GET IN

...it's what it costs to get out!

Meet a man of experience...he took a gamble, placed his money on a long shot and while he has now learned by experience, he didn't profit by it. *Barrels are worn in the business world, too.* Success is too often gambled on a chance to obtain lower costs and quicker production instead of choosing sound operating experience.

In the casting industry there is no substitute for experience. It insures dependable production and quality at the lowest, economical end cost. For over 35 years Monarch has developed the experience that underwrites our 3 major casting operations. We have every modern facility for the practical and economical production of aluminum permanent mold, aluminum die casting and zinc die casting.

Monarch "know-how" has enabled companies in every major industry to solve casting problems ... from initial engineering to final assembly. Monarch methods of production have been eminently successful and we are proud to say that Monarch customers are never seen "in barrels".

If you have a casting problem, let us offer a solution based on Monarch methods of production. Why not write us *today*?

MONARCH ALUMINUM MFG. COMPANY
DETROIT AVENUE AT WEST 93rd ST. • CLEVELAND 2, OHIO

3 casting divisions in 1 modern plant

ALUMINUM PERMANENT MOLD
ALUMINUM DIE CASTING
ZINC DIE CASTING

For Quality SPECIFY Monarcast

This Monarch Advertisement Originally Appeared in August, 1948

Its unusually significant message is even more important today...

Monarch, in one modern plant, offers completely integrated mass production facilities for quality-controlled aluminum permanent mold castings and high pressure aluminum and certified zinc die castings. Add to this the plus values of product finishing, complete product assembly and experimental development facilities, and you have a "production package" which few foundries are in a position to offer.

Monarch is ready to serve you now...with facilities, processes and specially trained personnel ...to provide practical solutions for your most complex casting problems.

Upon request, we'll send the complete "1948 series" of advertisements...also your copy of Monarch's FACT-FILE for busy design, purchasing and procurement executives.

MONARCH ALUMINUM MFG. COMPANY • ***Detroit Avenue at W. 93rd Street • Cleveland 2, Ohio***

dustry Co. Ltd. of Osaka and Tokyo. Initial plans call for the construction of facilities for the production of saran monomers and copolymers at Nobeoka, on the island of Kyushu, but Asahi-Dow expects also to manufacture saran filaments and might later engage in other lines of production.

♦

A new 16,000-sq ft addition to the plant of **Durant Mfg. Co.**, Milwaukee, provides space for new offices and plant production.

♦

American Machine and Foundry Co., New York, has signed an option to acquire all assets of **Leland Electric Co.**, manufacturer of electric motors. Leland operates a plant in Dayton, O., and another in Guelph, Ont.

♦

To insure the most efficient handling of its military orders, **Motorola Inc.**, Chicago, has established headquarters for its National Defense division in its 187,000 sq ft plant located on Clybourn Ave., Chicago. This entire plant, plus another 50,000 sq ft plant, will be devoted entirely to military production. Motorola also has a research laboratory in Phoenix, Ariz., devoted exclusively to development engineering on military contracts.

♦

Cleveland Industrial Tool Corp., Cleveland, has completed a $700,000 building and equipment expansion program for the further production of its hydraulic diamond turners and high precision aircraft parts.

♦

The jet engine center which the **General Electric Co.** is constructing at Lockland, O., was dedicated recently in commemoration of "the fastest ten years in aviation history." On March 18, 1942, the country's first turbojet was completed and placed on test at the Lynn, Mass., plant of GE.

♦

Plans for the expansion of fabricating facilities in the Pacific northwest were announced recently by **Aluminum Co. of America**, Pittsburgh. Immediate plans call for extensive modernization and revision of the ingot casting facili-

ties at the Vancouver, Wash., works. This current expansion is a forerunner of a projected plan to extend and diversify the fabrication of primary aluminum at Vancouver. Hydraulic extrusion presses and specialized wire working equipment are to be installed sometime in the future. The company also contemplates a modification of its existing rod rolling mill.

♦

The Udylite Corp., Detroit, will begin construction soon on a research laboratory building to be located on Hoover Ave. near Eight Mile Rd. Designed to provide complete facilities for every phase of research on electroplating and metal finishing processes, the structure will cover 16,000 sq ft. This new building will be the first unit of a long-term building project which will eventually house all of the company's manufacturing and administrative operations.

♦

American Machine & Foundry Co., New York, has purchased a majority of the stock of the **Thompson-Bremmer Co.,** Chicago, manufacturer of industrial fasteners and electrical terminals. The Chicago firm becomes a subsidiary of AMF and will operate as part of its General Products Div.

♦

Welding equipment manufacturing facilities of **A. O. Smith Corp.** have been moved into a 27,000 sq ft building separate from the company's main plant at Milwaukee. Besides providing space for assembly lines for welding machines, the building also houses experimental shops. Space vacated at the Milwaukee works is being utilized for expanded welding electrode production.

♦

Christiansen Corp., Chicago, producer of aluminum and magnesium alloy ingot, has announced the formation of a wholly-owned subsidiary named **Titanium Co. of America.** This corporation plans the construction of facilities for the manufacture of wrought titanium products. It is expected that the new plant will be located on the property in East Chicago where **Magnesium Co. of America,** another Christiansen subsidiary, has headquarters.

Association
ACTIVITIES

LESLIE B. BELLAMY, Cleveland Quarries Co., was elected president of the **American Society of Tool Engineers** for 1952-1953 at the society's 20th annual meeting held in Chicago. He succeeds J. J. Demuth of the National Production Authority in Washington, D. C. Other newly elected officers include: Roger F. Waindle, The Nugent-Sand Co. Inc., first vice president; Joseph P. Crosby, The LaPointe Machine Tool Co., second vice president; Dr. Harry B. Osborn, Jr., The Ohio Crankshaft Co., third vice president; H. E. Collins, Hughes Tool Co., secretary; and Gerald A. Rogers, Rudel Machinery Co. Ltd., assistant secretary-treasurer. Howard C. McMillen, Philco Corp., was re-elected treasurer and Harry E. Conrad of Detroit is executive secretary.

♦

The Penn State chapter of the **American Society for Metals** has announced the selection of William Wetzel Sieg as 1952 recipient of the David Ford McFarland Award. Mr. Sieg, whose selection was based upon his attainments in metallurgical industry and his outstanding work in civic affairs, is president of the Titan Metal Manufacturing Co.

♦

Industries working with or producing metal products are now being offered free assistance in their metal finishing or coating problems as a special service by the **Porcelain Enamel Institute.** A special committee has been established to research new applications of porcelain enamel and to provide the consulting, technical, or developmental assistance needed. Manufacturers who would like to obtain the services of this committee on any type of metal-product finishing or coating problem should write to the New Uses Committee, Porcelain Enamel Institute, 1010 Vermont Ave., N. W., Washington 5, D. C.

SALES AND SERVICE

Personnel

PROMOTION of **W. H. Thourlby** from manager of customer relations to manager of the Detroit sales division of The Standard Products Co., Cleveland, was announced recently. Concurrently, **Gordon McNeil** was named sales manager of the company's mechanical rubber division at Port Clinton, O. Mr. Thourlby joined the company in 1939 as Washington representative. He also served as an executive in military production works at the Port Clinton and Cleveland divisions before joining the Detroit sales office in 1945. He represented the company with automotive accounts before becoming manager of customer relations last year. Mr. McNeil first became associated with Standard Products in 1950 and has been chief engineer for the company's large tank track program.

♦

Dale D. Spoor, former chief of the Industries Branch of the Metalworking Equipment Division of NPA, has been appointed manager of the equipment and process sales department of Air Reduction Sales Co., a division of Air Reduction Co. Inc., New York.

♦

Lebanon Steel Foundry, Lebanon, Pa., has appointed **William H. Worrilow Jr.** to the position of general sales manager.

♦

Melvin G. Alderink has been assigned as a sales representative to the Duluth, Minn., branch office of the general machinery division of Allis-Chalmers Mfg. Co., Milwaukee. **Russell G. Michell,** an application engineer in the company's crushing, cement and mining section since 1950, has been assigned to the Boston district office of the general machinery division, also as a sales representative.

♦

Donald B. Stroud, sales engineer of Reliance Electric & Engineering Co., Cleveland, has been trans-

ferred from the company's Cincinnati district sales office to Indianapolis. His new headquarters are at 1840 East 38th St., Indianapolis, Ind.

♦

John E. Cinkosky has been appointed eastern zone manager of the Mercury Clutch Div. of Automatic Steel Products Inc., Canton, O. He will supervise the New England, middle Atlantic and south Atlantic territories.

♦

The Reliance Div. of Eaton Mfg. Co., Massillon, O., has announced the appointment of **Paul Byrd** as district manager of the Massillon territory. This territory includes portions of Ohio, Kentucky, Tennesse and all of Virginia and West Virginia.

♦

Steven P. J. Wood has been elected executive vice president of the Warner Electric Brake and Clutch Co., South Beloit, Ill. Mr. Wood joined the company in 1946 and has since served as both a sales and manufacturing executive.

♦

American-Fort Pitt Spring Div., H. K. Porter Co. Inc., Pittsburgh, has appointed **Millard F. Cornwell** as Philadelphia sales representative.

♦

Auburn Button Works Inc., Auburn, N. Y., custom molder of plastics, has named **George P. O'Neil** as sales representative in the western Pennsylvania territory. Mr. O'Neil, who is vice president of Allegany Plastics Co., Sewickley, Pa., will handle sales in this territory for both organizations.

♦

At a recent meeting of the board of directors of Lear Inc., Grand Rapids, Mich., **George K. Otis** was elected a vice president. He will continue as general manager of the company's LearCal Div., Los Angeles.

♦

Edwin M. Irish Jr. has been appointed phenolic products sales manager of the chemical materials department, Chemical Div., of General Electric Co., Pittsfield, Mass. Mr. Irish will be responsible for the

sale of phenolic molding compounds, laminating resins and industrial resins.

♦

Orville E. Isenburg has been appointed international sales manager for B. F. Goodrich Chemical Co., Cleveland, succeeding **James C. Richards,** who was elected vice president of sales recently.

♦

The Century Electric Co., St. Louis, Mo., has announced that **Roddy M. Pike** has been named district manager of its Cleveland office.

♦

Webster Electric Co., Racine, Wis., has announced the appointment of **James H. Lahey** to the newly created post of assistant sales manager of the oil hydraulics division. Previous to his new appointment Mr. Lahey spent two years as a sales representative in the company's industrial division.

♦

Wesley H. Hoffman, formerly Chicago district sales manager, has been promoted to the position of general sales manager of The Harrington & King Perforating Co., Chicago.

♦

Announcement has been made of the appointment of **Clarence A. Jarosz** as manager of industrial sales for Bendix-Westinghouse Automotive Air Brake Co., Elyria, O. Mr. Jarosz was formerly assistant sales promotion manager, and prior to that served as assistant service manager of the Air Brake Div.

♦

Diamond Chain Co. Inc., Indianapolis, manufacturer of roller chains, sprockets and flexible shaft couplings, has appointed **D. G. Viskniskki** as Chicago district manager. Mr. Viskniskki succeeds **S. C. Hurley,** who has retired.

♦

Dollin Corp., Irvington, N. J., producer of zinc and aluminum die castings, has appointed **Robert C. Kleindinst,** 1200 Niagara St., Buffalo 13, N. Y., as representative for the territory which includes northern Pennsylvania and New York state, with the exception of the New York metropolitan area.

S A L E S

Notes

TO SERVE New England, a new branch sales office and warehouse has been opened in Boston by **Minnesota Mining & Mfg. Co.,** St. Paul. The new one-story structure is located at 1330 Centre St., Newton Center.

♦

Wellman Bronze & Aluminum Co., Cleveland, has opened new offices for its executive, sales, accounting and purchasing departments at 12800 Shaker Blvd., Cleveland 20, O. The sales department was formerly located in the company's plant at 6017 Superior Ave.

♦

A branch operation of the **Fauver Co.,** of Detroit, **J. N. Fauver Co.,** newly established at 1534 Keystone Ave., Dayton 10, O., will distribute tube fittings, tube fabricating tools and related power plant accessories manufactured by the **Parker Appliance Co.,** Cleveland.

♦

Empire State Equipment Co., 36-38 Randall St., Providence, R.I., has been named a distributor for Texrope drive equipment for the state of Rhode Island by the general machinery division of **Allis-Chalmers Mfg. Co.,** Milwaukee. The latter company also recently announced the appointment of **Fenton Brothers Electric,** 235 Ray Ave., N. E., New Philadelphia, O., as a distributor for motors and controls is Tuscarawas county in Ohio.

♦

A major expansion of facilities for the manufacture and sale of rubber latex and plastic materials on the West Coast was announced recently by Naugatuck chemical division, **United States Rubber Co.,** New York. A new plant, which will be the division's western sales headquarters, has been completed on Telegraph Rd., Los Angeles, Calif. The plant will also contain customer technical service laboratories, facilities for the compounding and storage of natural and

synthetic rubber latex, and facilities for warehousing resins, plasticizers, rubber chemicals, agricultural chemicals and other products.

♦

A. Milne & Co., solid and hollow tool steel distributor, New York, has moved its San Francisco sales office and warehouse to new and larger quarters at 540 First St., San Francisco 7, Calif.

♦

To facilitate service and deliveries to customers, headquarters of the middle eastern states district of **DeVilbiss Co.** have been move from Cleveland to Toledo, O.

♦

Ampco Metal Inc., Milwaukee, has appointed **Kirk-Wicklund and Co.,** Kansas City, Mo., as a distributor of Weldrod products for the northern and eastern counties of Kansas.

♦

The Los Angeles branch office and warehouse of **Ward Leonard Electric Co.** have been moved to new larger headquarters at 1605 East Olympic Blvd., Los Angeles 21, Calif.

♦

Flexible Metal Hose Mfg. Co. is a new source, as a basic manufacturer for the trade, of flexible metal conduit serving a variety of shielding applications, and flexible metal hose for both fluids and gases. The company also makes all types of wire braiding in tin, copper, bronze, steel and other metals. The plant and general offices of the company are located at 640 West Seventeenth St., Costa Mesa, Calif., and sales offices are located at 8247 General Motors Bldg., Detroit, Mich., and 813 Munsey Bldg., Washington, D. C.

♦

The customer service department of **AiResearch Mfg. Co.,** Los Angeles, was recently moved to its own quarters in a 33,000 sq ft building adjacent to Los Angeles International Airport.

♦

Sterling Electric Motors Inc., Los Angeles, recently opened new sales offices at 1726 Champa St., Denver, Colo., and at 12 San Jose Ave., New Orleans, La.

Meetings

AND EXPOSITIONS

May 14-16—
Society for Experimental Stress Analysis. Spring meeting to be held at the Hotel Lincoln, Indianapolis, Ind. Additional information may be obtained from society headquarters, P. O. Box 168, Cambridge 39, Mass.

May 17-June 2—
Paris Fair to be held at the Port de Versailles, Paris, France. Additional information may be obtained from Rowland Associates, 420 Lexington Ave., New York 17, N. Y.

May 22-24—
American Society for Quality Control. Sixth annual convention to be held at Onondaga County War Memorial Auditorium, Syracuse, N. Y. Additional information may be obtained from society headquarters, 70 East 45th St., New York 17, N. Y.

June 1-6—
Society of Automotive Engineers. Summer meeting to be held at the Ambassador and Ritz-Carlton Hotels in Atlantic City, N. J. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

June 2-13—
Canadian International Trade Fair to be held at the Exhibition Grounds, Toronto, Canada. Additional information may be obtained from R. G. Pendrith, Publicity Section, Canadian International Trade Fair, Toronto, Canada.

June 4-10—
International Mechanical Engineering Congress. Fourth congress to be held at the Gillet Hotel, Brunkebergstorg, Stockholm. C. de Novar, 10 Avenue Hoche, Paris 8, France is permanent secretary.

June 9-21—
International Organization for Standardization. Triennial meet-

ing to be held at Columbia University, New York, N. Y. The American Standards Association, U. S. member of the ISO, will act as host. Additional information may be obtained from American Standards Association, 70 East 45th St., New York 17, N. Y.

June 15-19—
American Society of Mechanical Engineers. Semiannual meeting to be held at the Sheraton-Gibson Hotel, Cincinnati, O. C. E. Davies, 29 West 39th St., New York, N. Y. is secretary.

June 16-18—
American Society of Agricultural Engineers. 45th annual meeting to be held at the Muehlebach Hotel, Kansas City, Mo. Raymond Olney, P. O. Box 229, St. Joseph, Mich., is secretary.

June 16-20—
American Electroplaters' Society. Third Industrial Finishing Exposition to be held at the International Amphitheatre, Chicago, Ill. This meeting is being held in conjunction with the 39th annual meeting of the AES which will take place at the Conrad Hilton Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 35 East Wacker Drive, Chicago 1, Ill.

June 19-21—
American Society of Mechanical Engineers. Applied mechanics division conference to be held at Pennsylvania State College, State College, Pa. C. E. Davies, 29 West 39th St., New York, N. Y. is secretary.

June 23-27—
American Society for Testing Materials. The 50th annual meeting to be held at the Hotel Statler, New York, N. Y. Additional information may be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

June 23-27—
American Society of Mechanical Engineers. Oil and gas power division conference to be held at the Hotel Statler, Buffalo, N. Y. C. E. Davies, 29 West 39th St., New York, N. Y. is secretary.


SELL YOUR BRASS
MILL SCRAP PROMPTLY
To keep production rolling
Help lick the shortage of brass and copper. Make sure that every pile of brass mill scrap in your factory – even if it is only a hundred pounds – is sold at once.
Not only is this scrap immediately salable on today's market – it will bring vital metal to the production lines where it is sorely needed.
Both the defense program and civilian needs require more and more copper and brass. To prevent increased shortages and even more stringent regulations, see that *your* brass mill scrap is moved promptly.
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New York Philadelphia Pittsburgh Providence Rochester† St. Louis
San Francisco Seattle Waterbury
(†sales office only)

New Machines

Heating and Ventilating

Portable Air Cooler: Direct drive blower Model No. B-1800-PI, especially adapted for window installation. For small apartments, rooms, offices, trailers, etc. Adjustable grille directs air flow in desired direction. Cooler may be filled by hand or by automatic float valve to maintain constant water level in reservoir. Trough type water distribution system delivers water to aspen cooler filter pads. Cooler may be used for ventilation and cooling effect, or circulating filtered air only. Size: 21 in. high, 24 in. wide, 15 in. deep. Capacity, 1000 cfm. *Palmer Mfg. Corp., Phoenix, Ariz.*

Portable Furnace: Furnishes heat or circulates cool air. Delivers 189,000 Btu of heat per hour. Heat is sprayed out at floor level over area of approximately 3000 sq ft. Converted to cool air blower by changing top blower mounting. Delivers 1500 cfm of cool air. *Fageol Heat Machine Co., Detroit, Mich.*

Air Conditioners: Feature integral evaporative condensers. Capacities of 15 and 20 tons. Has multistep reciprocating compressor which steps down power consumption automatically when reduced cooling is required. Fan motor and pump of evaporative condenser are mounted in conditioner-compressor section, where they are not exposed to moist conditions. Moisture condensed from atmosphere by cooling coil is added to spray water in condenser. Cuts overall water consumption as much as 98 per cent on humid days. For use where water is either scarce or of abnormally high temperature. *The Trane Co., La Crosse, Wis.*

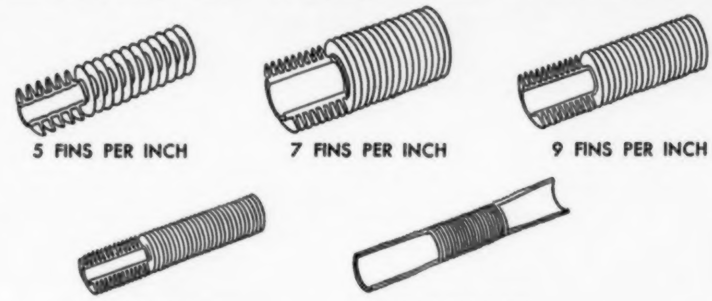
Industrial Dehumidifier: Model WA-5 can be supplied in three different ways: (1) for continuous or intermittent operation without automatic control; (2) with optional plug-in control so that automatic operation is effected by plugging the unit into the control, plug-

WOLVERINE TRUFIN*

offered in a

Wide Choice of Combinations

CHOICE OF THESE FIN SPACINGS



CHOICE OF THESE METALS

Copper, copper base alloys, aluminum, or in bi-metal—having aluminum fins with liners of copper, copper base alloy, or steel.

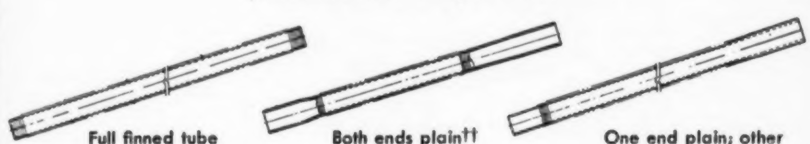
CHOICE OF SIZES

Inside diameters from ¼" to 1" †
Outside diameters of fin from ½" to 2" nominal

†For further detailed information request Bulletin 651.

CHOICE OF THESE END TREATMENTS

(Available in 19 fins per inch)††



††Full finned end furnished in all sizes

AS EASILY FABRICATED AS PLAIN TUBE

Trufin, the integral finned tube—can be fabricated as easily as plain tube—can be bent to unbelievably small radii to achieve extreme compactness. Trufin is suitable for nearly all kinds of heaters, coolers, interchangers, condensers and many other heat transfer applications. WOLVERINE TUBE DIVISION, Calumet and Hecla Consolidated Copper Company, Inc., Manufacturers of seamless, nonferrous tubing, 1433 Central Ave., Detroit 9, Mich.

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PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
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Export Department, 13 E. 40th St., New York 16, N. Y.

ging the control into an electric outlet, and setting the dial of the control at percentage of humidity desired; and (3) with control built into front of unit. Size: 13 by 13 by 29½ in. high; weight, 86 lb. *Abbeon Supply Co., Jamaica, N. Y.*

Materials Handling

Belt Trainer: Automatically keeps conveyor belts aligned. Can be installed on any make of conveyor which has return belt exposed beneath bed. For use on fabric or rubber-covered belts 3/16-in. or more thick, operating at speeds up to 200 fpm. Trainer is bolted to flanged rails on underside of conveyor. Flat sides of belt run between two sets of knurled spring loaded rollers, with belt edges contacting two sets of equalizer posts. If belt creeps to either side it presses against the posts and cocks spring-loaded knurled rolls to alter belt direction. This brings belt back into alignment, and trainer mechanism returns to normal setting for further control. *The Rapids-Standard Co. Inc., Grand Rapids, Mich.*

Live Roller Conveyor: Available in widths from 6 to 36-in. wide. Rollers are 2-in. in diameter and spaced to meet requirements. Rolls are driven by belt passing underneath. Standard speed of 50 fpm may be increased or decreased as desired; variable speeds also available. *Sage Equipment Co., Buffalo, N. Y.*

High Lift Truck: Hydraulic model with 1000-lb capacity. Available in nontelescopic model having 60-in. elevated height and telescopic model which elevates to 108 in. Has either auto steer or swivel casters. Hand or power elevation. Size of platform, 24 by 36 in. *The Raymond Corp., Greene, N. Y.*

Drum Up-Ender: Permits fork truck operator to pick up, transport, stack and empty heavy drums without leaving his seat. Drums can be rotated 90 deg for vertical or horizontal stacking, or tilted 45 deg below horizontal for emptying at any height within lift range of truck. Attachment has shoes which fit on forks of truck. Pivoted rubber-faced grab plates mounted on shoes clamp around drum and hold it firm. Up-ending operation is

accomplished through hydraulic cylinder mounted on one of the shoes. Operation of hydraulic cylinder builds up pressure in an actuating accumulator mounted above it, which is used to return drum to an upright position. Can be mounted on 2000, 3000 and 4000-lb Baker fork trucks. *Baker-Raulang Co., Baker Industrial Truck Div., Cleveland, O.*

Table Conveyors: From 6 to 36 in. wide, with rubber, solid woven cotton or stitched canvas belt. Standard table heights, 32 or 36 in.; other heights available. Can be equipped with side leaves on both sides or one side. Constant or variable speeds. *Sage Equipment Co., Buffalo, N. Y.*

Utilities Rack: For handling parts or small items in the course of production or assembly. Has two swivel and two rigid casters. Standard dimensions: 24 in. wide, 50 in. high, 48 in. long; clearance between shelves, 12 in.; weight, approximately 220 lb. *Palmer-Shile Co., Detroit, Mich.*

Drum-Carrying Lift Truck: Tray-Hart drum carrier mounted on 3000-lb capacity Jeep truck carries four drums. Front of carrier may be used to push drums into pick-up position. Misalignment compensator automatically shifts carrier up to a maximum of 4 in. when lift truck is not in line with load. Drums are placed into gripping position as drum carrier frame is lowered over the load. Gripping shoes have non-slip lining. Hydraulic power unit controls load-releasing mechanism by applying pressure which retracts gripping shoes. Size, 54 in. long, 51 in. wide. *Mercury Mfg. Co., Chicago, Ill.*

Metalworking

Mill Type Bolt Cutter: Model 30-MCC has double-edged cutting blades which can be reversed. Blades may be resharpened when necessary. Capacity, ½-in. diameter bolts or ⅜-in. diameter steel rod. Eccentric head strap and fulcrum bolts maintain tension for easy action. *Manco Mfg. Co., Bradley, Ill.*

Electric Piercing Press: Requires no hand or foot levers to trip machine; it is put into operation through two contacts on a magnetic

stripper plate. Punches holes up to ½-in. in diameter in materials up to 3/16-in. thick. Ram of press is in bed of machine and punches on upstroke. Will receive standard Allied punch and die and is provided with a nonrepeat mechanism. Machine is mounted on casters. *Dayton Rogers Mfg. Co., Minneapolis, Minn.*

Molding Machine: Jolt-squeeze-strip unit developed for speed and efficiency in production of massive cope and drag molds. Features pushbutton actuation of all operations. Operates on conventional air pressure. Has squeeze capacity of 80,000 lb and jolt capacity of 4000 lb. Flask space ranges from 38 in. minimum to 54 in. maximum, left to right, and from 32 to 50 in., front and back. Squeeze cylinder diameter, 36 in.; pattern draw, 14 in.; squeeze piston stroke, 14 in. Stands 166 in. high, with 50 in. recessed below floor level. *SPO Inc., Cleveland, O.*

Hole Punching Machine: For mild steel up to ¾-in. thick. Features compressed fluid Hydra-Spring, which provides more stripping pressure than mechanical springs of the same volume. Loads may be changed by adjustment to increase or decrease volume of fluid. *Wales-Strippit Corp., North Tonawanda, N. Y.*

Metal Joiner: Automatically seams sheet metal of any thickness from 18 to 30 gage in 40 seconds. Exerts 11,000 psi pressure. Works from pressure derived from force which roller assembly exerts against an overhead structural steel beam. Joiner travels in one direction; automatically reverses direction for a second and final operation which smoothes the seam. Handles square or round piping or straight seaming up to 8 ft long. Size of machine, 10 ft overall. *Standard Power Groove Machine Corporation, New York, N. Y.*

Internal - External Grinder: Grinds holes up to 3-in. diameter, with a maximum 4-in. depth, depending upon diameter; grinds externally up to 3-in. diameter with a length of 4 in. Has interchangeable motor-driven wheelheads for internal and external operations. Internal spindle can be selected with removable arbor and chuck

for mounted wheels, or with solid shaft, for speeds of 12,000 to 35,000 rpm. Lathe type spindle in workhead takes collets or step chucks directly. Has mechanical power table traverse with infinite speed and stroke adjustment within ¼-in. to 4-in. stroke; hand table travel with both coarse and fine feeds to 0.001-in. Workhead swivels 90 deg each side of center for bevel and taper grinding and has speeds of 200, 400 and 600 rpm. *Rivett Lathe & Grinder Inc., Boston, Mass.*

Power Press: Capacity, 60 tons. Features heavy duty one-piece special alloy frame with built-in tierods of high tensile steel. Tierods provide extra reinforcement to gap of the press. Has extra heavy ramslide with large and long ramways. Available in either back-geared or flywheel types. Has clutch mounted on crankshaft only. Bolster area, 21 by 32 in.; depth of throat, 11 in. *Sales Service Machine Tool Co., St. Paul, Minn.*

AC Welders: New line features silicone insulation; combination of low open circuit voltage with arc stabilization, accomplished by incorporating capacitors in the secondary circuit to provide an extra surge of current if the arc starts to go out; and automatic hot-start, which provides current boost to start the arc at any current setting without manual adjustment. Welders made in 200, 300, 400 and 500-amp ratings. *Metal & Thermit Corp., New York* 17, *N. Y.*

Portable Arc Welders: Model 200A operates from 110 or 220 volts with a heat range of 20 to 200 amp, handling rods up to 3/16-in. on work up to 1¾-in. thick. Models 300A and 400A operate from 220/440-v lines, each with 36 different heat stages, ranging from 30 to 300 amp and 400 amp, respectively. Feature eye level control panel to simplify heat selection from all operating angles. *Trindl Products Ltd., Chicago, Ill.*

Boring Machine: Manufactured by Rovai Jori of Italy. Head slides along a ground column which is bolted to bed and has a scale with vernier and lens to measure vertical travel of head. Speed changes accomplished through series of honed alloy steel gears immersed in an oil bath and mounted on roller bearings. Revolving table

The Dayton "Twins" solve *any* V-Belt problem!

For general purpose drives . . . over regular-diameter pulleys!

The famous Dayton Thorobred, with *three prime section* construction, is ideal for regular drives. 1. *Tension* section flexes easily over pulleys, without straining or cracking. 2. *Strength* section features electronically processed cords, for greater strength, and better bond with other sections of belt. 3. *Compression* section runs cool, gives more crosswise rigidity.

For "tough" drives...and to save space and weight.

The Dayton Cog-Belt*—for tough drives, or small pulleys! Scientifically built to bend as naturally as your finger, this premium belt delivers 40% more horsepower than conventional V-Belts. Easier bending lets you design drives with shorter center distances . . . smaller pulleys . . . 28% less weight . . . 47% less space. And even more important—5 Cog-Belts do the work of 7 conventional V-Belts!

*T.M.

Let Dayton help with your drive design problems. No obligation, of course. Just write, wire or phone DAYTON RUBBER COMPANY, DAYTON 1, OHIO.

V-Belts by Dayton Rubber

Since 1905

WORLD'S LARGEST MANUFACTURER OF V-BELTS

may be displaced both horizontally and longitudinally. Chuck is mounted and supported by two bushings and an adjustable bronze taper bearing. Axial load is absorbed by thrust bearings mounted to back support. *British Industries Corp., International Machinery Div., New York, N. Y.*

Nut Runner: Pneumatic model MA-25 gives precise torque control in 0 to 25 in-lb range. Special gearing available to extend torque range to 40 in-lb. Used on production jobs where too much torque would cause breakage or distortion of light metal parts, castings or plastic. Desired torque is set by using built-in torque wrench as gage. Accurate to 2 per cent of torque limits. *Garvin Brothers Inc., South Bend, Ind.*

Staking Press: Model RR-6B bench-mounted unit for light staking, forming, and other secondary press work. Has built-in quick-exhaust valve and simplified air ejection system to remove work automatically from lower die. Delivers accurately controlled impact from 0 to 12,000 lb or squeeze up to twelve times air line pressure. Stroke may be set for 1 or 2 in. Model 300 slide feed for use on RR-6B press features built-in hydraulic control of slide speed, stroke of 2 or 3 in., adjustable as desired, adjustable air-blow-off of work, safety guard and attached small parts tray. *Winter Products Inc., Bridgeport, Conn.*

Pulverizing Mill: Impact type, pulverizes dry, grindable material to specifications without damaging molecular structure. Disintegration of material is accomplished by impact against surfaces and by impact of material against itself. Powered by 1-hp motor, output is 50-100 lb per hour. Other models available in sizes ranging from 5 hp with output of 500 lb per hour to 30 hp with output of 16,000 lb per hour. *Mead Mill Co., Detroit, Mich.*

Pneumatic Grinders: "Shorty" grinder features comfortable hand fit, exhaust that directs air away from operator toward wheel to cool and clean work, chuck guard, noise silencer. Can be used with accessories such as mandrel mounted abrasive wheels and points; rotary

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ROYAL FAMILY OF PLASTICS
Known by the customers we keep . . .
Here are just a few of our many customers...and the products we helped them make finer.
Combs
Vulcanized Rubber & Plastics Company
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Sponge Rubber Products Company
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Parker Pen
Parker Pen Company
KRALASTIC
Tote Boxes
American Optical Company
KRALASTIC
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Horsman Dolls, Inc.
MARVINOL
Pipe Fittings
Orangeburg Manufacturing Co., Inc.
MARVINOL
Household Fabrics
Elm Coated Fabrics Company
MARVINOL
TV Antenna Insulator
Lanfare Molded Products, Inc.
VIBRIN
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Division of
United States Rubber Company
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Marvinol® vinyls
Kralastic® styrene copolymers
Vibrin® polyesters

files; carbide burrs; wire brushes; shaping and finishing attachments for dies, molds, castings, forgings, patterns; etc. Has maximum 0.0015-in. arbor runout. Weighs 18 oz; is 5¼ in. long. Model No. PGK2122L is heavy-duty tool for extreme accuracy on large grinding jobs. Used for rotary filing on aluminum and magnesium castings or any fast, large-scale grinding job. Extended spindle allows greater pressure on work. Has four-vane rotary motor adjustable to various speeds. Features vibration elimination and noise silencing. Weighs 1¾ lb. *Mall Tool Co., Chicago, Ill.*

Cut-Off Machine: Automatically cuts pipe and tubing up to 12 in. in diameter. Operator feeds pipe to adjustable stop and operates foot switch. Air cylinder, precision electrical controls and air mechanism gage speed at which blade approaches the pipe. When foot switch is actuated, the pipe starts spinning slowly as the blade engages it, then heavy cutting pressure is exerted. Blade retracts automatically after each cut. *Continental Machine Co., Chicago, Ill.*

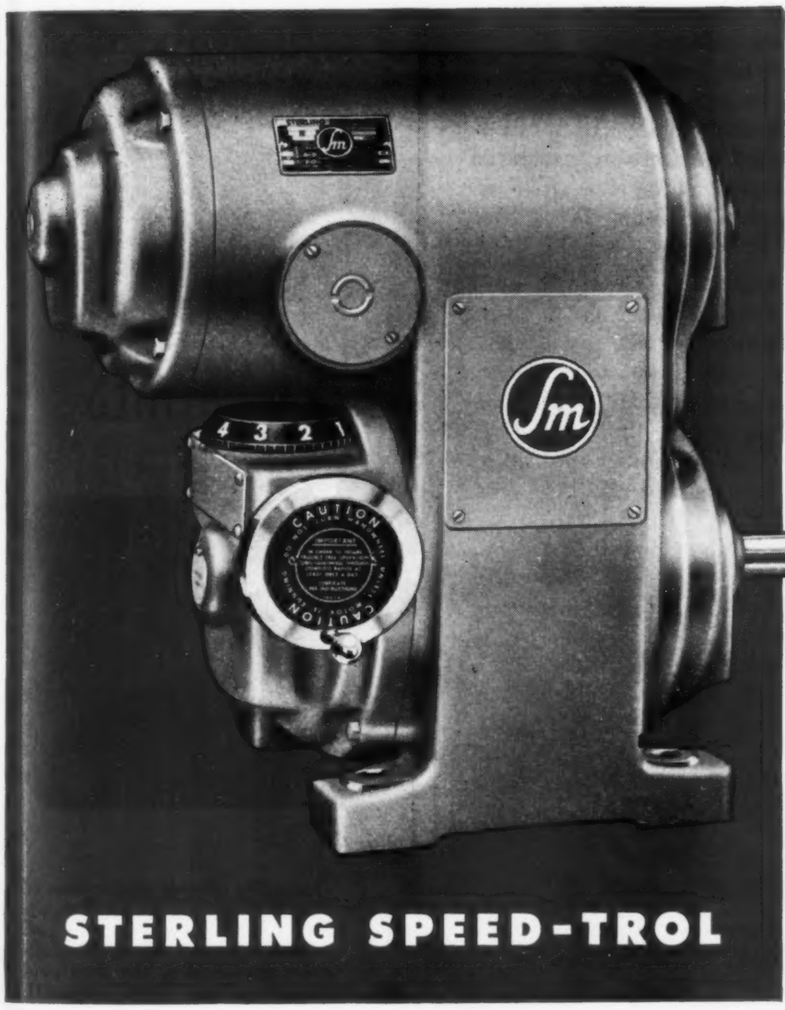
Portable Stud Welder: Features simple operation. Operator loads a stud in the collet and applies light pressure to spring-loaded stud holder which fires the stud. Handles variety of stud sizes and shapes, including hooks and headed studs in sizes up to ½-in. diameter. Operates on 110, 220 or 440-v alternating current. *Graham Mfg. Corp., Detroit, Mich.*

Squaring Shear: Features simple and economical operation. Operates on 70 or 80 psi air pressure. Depressing foot valve automatically clamps the holddown and lowers the crosshead to complete the cut. Flexible air hose for treadle permits the operator to trip the shear from any convenient location. Adjustable ways are made of laminated plastic. Machine has front brackets, a long front gage bar and two side gages. *Niagara Machine & Tool Works, Buffalo, N. Y.*

Plant Equipment

Carbide Tool Grinder: Manufactured by Moteurs Constan of France. Grinds all types of carbide tools. Attachment available for

PRODUCTION UP 25% & QUALITY IMPROVED WITH



STERLING SPEED-TROL!

By replacing constant speed motors with Speed-Trol variable speed drives on machines for picking and garnetting worsted and woolen threads and clips, we improved quality of garnetts, increased production as much as 25%, reduced direct labor and power costs, reports Carl Simon, President of Carlsons' Garnetting Mills, Inc. Speed-Trols enable us to accurately adjust machine speed for maximum production of each type and quality of material under varying atmospheric conditions.

STERLING SPEED-TROL GIVES YOU VARIABLE SPEED CONTROL NECESSARY FOR:

EQUIPMENT ADAPTATION TO: Sequence synchronization—operators' abilities—load variations due to differences in quantity, quality, weight, size, tension, hardness or shape of material to be processed, machined, conveyed, blended, mixed, etc.

PROCESS CONTROL OF: Temperature—viscosity—level—pressure—flow—etc.

TIME CONTROL OF: Baking—drying—heating—cooking—pasteurizing—soaking—chemical action—etc.

With Speed-Trol you get the maximum in production, plant efficiency, quality and profit.

70 ILLUSTRATIONS showing how Sterling Electric Power Drives reduce production costs. Write for Bulletin No. A102.

OTHER STERLING ELECTRIC POWER DRIVES:

- **STERLING SLO-SPEED (GEARED) MOTORS**
- **STERLING KLOSD AND KLOSD-TITE (NORMAL SPEED) MOTORS**

DRIP-PROOF • SPLASH-PROOF • TOTALLY ENCLOSED

STERLING ELECTRIC MOTORS

Plants: New York City 51; Van Wert, Ohio; Los Angeles 22; Hamilton, Canada; Santiago, Chile.

Offices and distributors in all principal cities.

grinding carbide inserted tooth milling cutters. Includes universal ball and socket vise combined with an inclinable table, permitting tool clamping in any position. Compound angles easily read. Constant clearance angles obtainable on tools having radii or complicated profiles. Wheel head consists of a motor carrying a diamond wheel at each end—one wheel for roughing and one for finishing. Has built-in coolant system. Coolant is sprayed out by centrifugal force through holes in the center of wheels. Wheels are raised or lowered by two-speed handwheel. Has radius setting gage, as well as graduated dials for positioning the tool. *H. E. B. Machine Tools Inc., New York, N. Y.*

Dust Collector: Develops 5500 cfm at 4-in. of water on a 12-in. inlet. Has motor driven fan, cyclone separator, and dust storage compartment. For industrial dust including abrasives, lint and chips generated in grinding, polishing, buffing, turning and milling operations; dust control in the woodworking, chemical, and food processing industries; and for installations where dust containing toxic elements must be discharged out of doors. Equipped with 10-hp continuous duty motor which drives the self-clearing fan through a series of V-belts. Size of base, 34 by 60 in.; overall height, 94 in. *Aget-Detroit Co., Ann Arbor, Mich.*

Processing Equipment

Volume Delivery Material Pumps: Two models available—one designed for use with 55-gal drums: the other equipped with a 10-gal hinged lid tank into which a standard 5-gal paint container can be fitted. Adapted for simple direct hose line connections, through which as many as six spray guns can be operated directly from a single pump. Feature automatic by-pass valves which enable operator to maintain paint mixtures at correct consistencies and control fluid pressure. *The DeVilbiss Co., Toledo, O.*

Induction Furnace: For high-speed production of precision castings. Transfers molten metal from furnace to mold in preset cycle. At end of melting period (12 min-

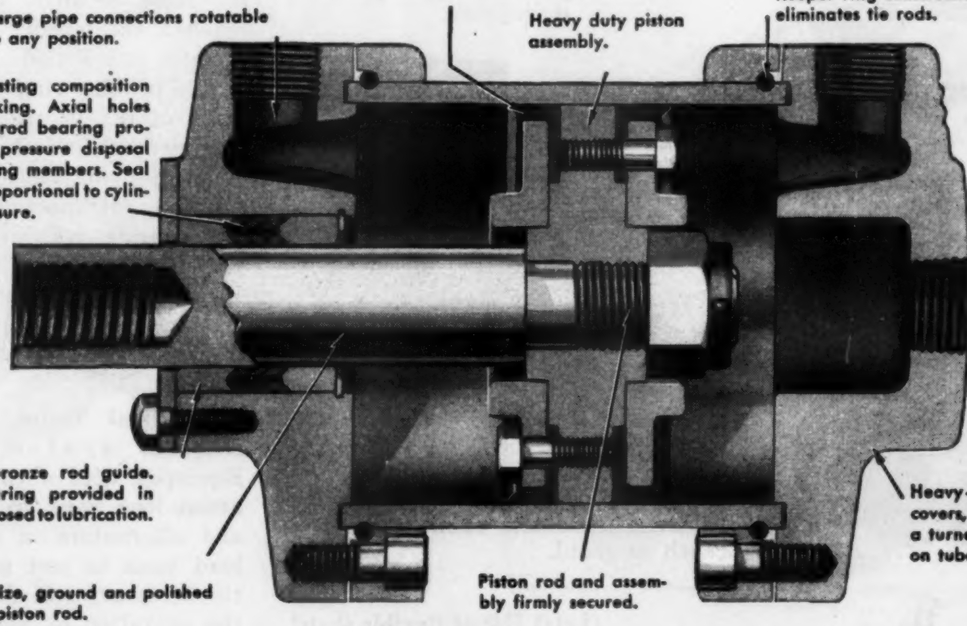
Avoid air power failure!

Choose Rivett Air Cylinders

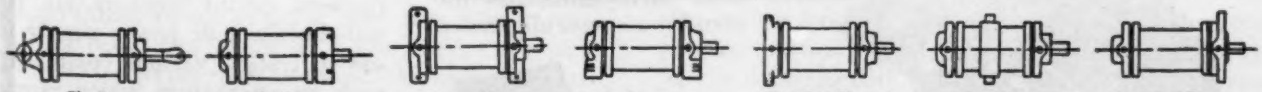
The importance of smooth, steady cylinder performance cannot be over-emphasized in today's production. Only too often a whole line is slowed down, or stopped altogether because of a faulty cylinder.

You can rely on Rivett air cylinders to provide dependable service. Study the construction features shown below. They represent many years of practical cylinder design—and are the basis on which thousands of satisfied customers have purchased Rivett.

Recommended for pressures up to 150 P.S.I., Rivett air cylinders are available in 7 standard mountings; in 9 bore diameters, in any length stroke up to 96", single or double-end rods, with internal or external thread, and cushioned rod end, blind end, or both. Special covers supplied. Send today for Catalog Section 55.



SEVEN STANDARD MOUNTINGS

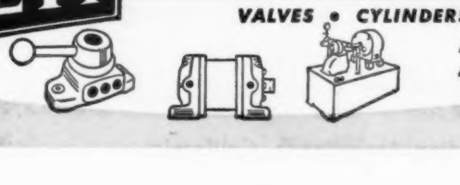


RIVETT LATHE & GRINDER, Inc. • Dept. MD 5, Brighton 35, Boston, Massachusetts

RIVETT furnishes a complete power package

VALVES • CYLINDERS • POWER UNITS

Air and Hydraulic
All sizes and types



utes for 5 lb of alloy steel), preheated mold or investment is clamped directly to top of crucible. Operation of control lever rotates furnace to pouring position. Powered by 20-kw mercury hydrogen type converter; operates at a frequency of about 30,000 cycles. Converter can also be used to power other melting furnaces, or for various types of heating equipment for heat treating, brazing, etc. *Ajax Electrothermic Corp., Trenton, N. J.*

Testing and Inspection

Compression Testing Machine: Portable hydraulic model for many types of small metal, ceramic, wood and plastic parts. Load is applied to test specimen through a hydraulic system actuated by compressed air. Load applied to specimen is indicated on dial of a double proving ring. When capacity of the more sensitive outer ring is reached, the heavier inside ring is brought into action. Low range of double proving ring is sensitive to loads of 0.1 lb. Load applied to specimen is indicated on dial of double proving ring. Load can be released instantaneously at any time during test or at point of failure. Capacity, 350 lb under operating air pressure of 100 psi; machines with capacities up to 1000 lb can be supplied. *Labquip Corp., Chicago, Ill.*

Universal Tester: For aircraft electrical system components. Equipped with a three-phase balanced load bank to test inverters and alternators, a direct current load bank to test generators and the necessary test circuits to check the operation of voltage and current regulators, control relays, flashers, circuit breakers, etc. Has self-contained dc power supply for use in testing various components such as alternators which require external excitation. Load banks are so designed that interlocks prevent their use for testing unless ventilation fans are in operation. High capacity blower provided to assure proper cooling of generators. *Greer Hydraulics Inc., Brooklyn, N. Y.*

Monochromatic Light: Has 10 times capacity of previous model. Features built-in power unit and adjustable helium light which can

DIAMOND ROLLER CHAINS AID 30 YEARS OF SANDMASTER PROGRESS

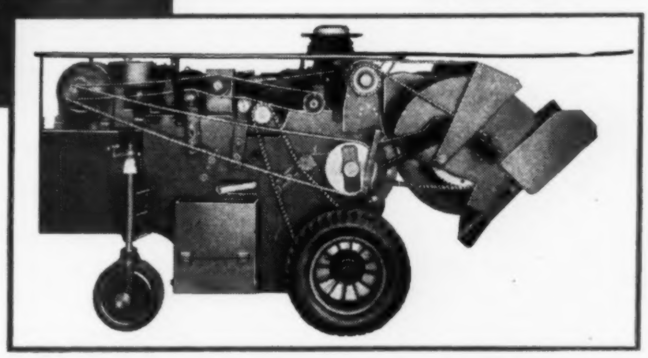
ON THIS 1921 MODEL →

AND ON THIS LATEST MODEL

Called the Sand Cutter, this early model proved the economy of mechanical sand conditioning.

Based on long experience, this American Sandmaster incorporates added features. Diamond Roller Chains perform many operations.

This stripped view of Sandmaster shows how the design engineers employ Diamond Roller Chains to coordinate the many operations.



• Seeking a method to speed sand conditioning in foundries, American Wheelabrator engineers developed the Sand Cutter shown at top of page over 30 years ago. It will be noted that Diamond Roller Chains provided the means for locomotion and sand cutting operations.

Today's streamlined Sandmaster cuts, separates, screens, and piles at high speed and low cost. As in the early models, this, too, is equipped with Diamond Roller Chains for various numerous operations as the illustration above shows.

On equipment you produce or purchase, — on the machinery drives in your plant, you can always expect the maximum in efficient non-slipping performance that insures long-life high output. For peace-time competition and war preparedness production, you can rely on the dependability of power transfer that Diamond Roller Chains provide.

DIAMOND CHAIN COMPANY, Inc.
Dept. 435, 402 Kentucky Avenue, Indianapolis 7, Indiana
Offices and Distributors in All Principal Cities

DIAMOND ROLLER CHAINS

be raised, lowered, and turned 360 deg to suit any inspection job. Has 5 by 5½-in. high-intensity helium tube light source providing 53 foot-candle illumination on testing stage. Light source provides interference bands at 0.0000116-in. intervals; when used with accurate optical flats can be used to measure size, flatness and parallelism to within a few millionths of an inch. Standard stage is 6⅛ by 4⅛-in. phenolic plate. Storage space under hinged work stage accommodates six 2-in. optical flats or three each 3-in. or 4-in. flats. Maximum height, stage to light, 9 in.; maximum height, table to light, 16 in.; height closed, 9½ in.; width, 8 in.; length, 11¾ in.; weight, 30 lb. *DoAll Co., Des Plaines, Ill.*

Dual Head Test Stand: For determining operating characteristics of aircraft generators, vacuum pumps, alternators, magnetos, hydraulic pumps, etc. Dual head permits wider variation in take-off speeds and permits testing of two components at one time. Consists of variable speed motors on which are mounted brackets to accommodate various components to be tested. Horsepower for continuous duty is from 7½ to 50; for intermittent duty, from 10 to 75. Ratio between the two take-off shafts is usually 2:1. Speeds and ratios may be changed to meet particular requirements. Can be supplied with a tachometer which will give direct rpm readings for both take-off shafts. *U. S. Electrical Motors Inc., Los Angeles, Calif.*

Optical Comparator: Has 16-in. diameter image screen and plain horizontal work stage platform. Condenser lens is exhaust power cooled. Light source may be used with color filters to vary intensity and shading of light on the screen. Magnifications of 10X, 20X, 31.25X, 50X, 62.50X and 100X obtainable as standard equipment. Production type fixtures may be mounted on working stage for various classes of work. Image screen has provision for mounting of overlay chart holders to facilitate changing over of charts from one job to another. Size of working stage, 6 by 16 in.; overall height of unit, 30 in.; width, 20 in.; depth, 45 in.; weight, 350 lb. *Portman Instrument Co., Port Washington, N. Y.*